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EcoPredictAI: An Intelligent Web-Based Carbon Footprint Tracker with Predictive Analytics and AI-Driven Recommendations

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Abstract:
EcoPredict AI is an intelligent web-based platform developed using the MongoDB, Express.js, React, and Node.js stack to help individuals track, analyze, and reduce their carbon footprint. The system allows users to input daily lifestyle activities such as transportation usage, electricity consumption, food habits, and waste generation. Based on these inputs, the platform calculates the user's carbon emissions and provides a clear overview of their environmental impact. The application integrates the OpenAI API to generate intelligent insights and personalized recommendations that help users adopt more sustainable habits. Using historical user data, the system can also analyse emission patterns and forecast future carbon footprints through predictive models and data analytics techniques. The platform presents these insights through an interactive dashboard with visual charts and trend graphs, enabling users to monitor their daily, weekly, and monthly CO_2 emissions. EcoPredict AI aims to promote environmental awareness by transforming complex emission data into simple, actionable insights. EcoPredict AI addresses this gap by providing an intelligent web-based platform built on the MERN stack (MongoDB, Express.js, React, Node.js) that enables users to track, analyze, and reduce their carbon footprint. Users input lifestyle data across categories such as transportation, electricity usage, dietary habits, and waste generation. The system calculates CO_2 emissions using established conversion factors and presents the results through interactive dashboards featuring visual charts and trend graphs. By leveraging the OpenAI API, EcoPredictAI generates personalized, actionable recommendations to help users adopt greener habits. Additionally, historical data is used to forecast future emissions through predictive modeling, empowering users to anticipate their environmental impact and set reduction goals. The platform combines artificial intelligence, data analytics, and a user-centric interface to transform complex emissions data into simple, engaging insights. This work demonstrates that a well-integrated AI-powered tracking system can significantly enhance environmental awareness and encourage sustainable behavior change.

Keywords: Carbon Footprint, MERN Stack, Predictive Analytics, OpenAI API, Sustainability, AI Recommendations, Environmental Awareness

I. INTRODUCTION

Environmental sustainability has become a critical global concern due to the increasing levels of carbon

emissions and their impact on climate change. Many daily human activities such as transportation, electricity consumption, food choices, and waste generation contribute significantly to the production of carbon dioxide (CO_2). The total amount of greenhouse gases produced directly or indirectly by these activities is known as a carbon footprint. Monitoring and managing personal carbon footprints can help individuals understand their environmental impact and encourage sustainable living. EcoPredict AI is a smart web-based application designed to track and analyze an individual's carbon footprint. The system allows users to input their daily lifestyle activities, including travel distance, electricity usage, food habits, and waste generation. Based on these inputs, the platform calculates the estimated carbon emissions and presents them in a clear and structured format. The application is developed using modern web technologies such as React, Node.js, Express.js, and MongoDB. It also integrates the OpenAI API to generate personalized recommendations and insights that help users reduce their carbon emissions. The platform provides an interactive dashboard with charts and emission trends, enabling users to monitor their environmental impact over time. By combining artificial intelligence, data analytics, and user-friendly design, EcoPredict AI encourages individuals to adopt eco-friendly habits and contribute toward a more sustainable future.

Climate change is one of the most pressing challenges of the 21st century, driven largely by anthropogenic greenhouse gas emissions. The concept of a carbon footprint—the total amount of CO_2 and other greenhouse gases emitted directly or indirectly by an individual, organization, or activity—has emerged as a critical metric for understanding and mitigating personal environmental impact. According to the Intergovernmental Panel on Climate Change (IPCC), immediate and sustained reductions in emissions are necessary to limit global warming to 1.5°C above pre-industrial levels. Individual actions, when aggregated, can contribute substantially to these reductions; however, a lack of awareness and actionable guidance often hinders behaviour change.

II. Literature Review and Domain Analysis

2.1 Carbon Footprint Calculators. The concept of a personal carbon footprint gained prominence in the early 2000s, leading to the development of numerous online calculators. Early tools, such as the U.S. Environmental Protection Agency's Carbon Footprint Calculator, relied on simple questionnaires and static emission factors to provide a single estimate. These calculators typically focus on home energy, transportation, and waste. While useful for raising awareness, they offered limited interactivity and no longitudinal tracking. More recent platforms, such as the WWF Footprint Calculator and the Carbon Trust's tools, have incorporated more detailed categories and better user interfaces. However, most remain static—users enter data once and receive a snapshot result. Research by Druckman and Jackson (2009) emphasized that to effectively motivate behavior change, calculators must provide ongoing feedback and contextualized information. Similarly, a study by Mulrow et al. (2019) found that users engage more deeply with applications that offer personalized suggestions and allow tracking over time.

2.2 AI and Machine Learning in Sustainability. Artificial intelligence has been increasingly applied to environmental sustainability. In the context of carbon accounting, machine learning models have been used to estimate emissions from heterogeneous data sources, such as satellite imagery and smart meter readings (Rolnick et al., 2019). For personal footprint tracking, AI can play a role in automating data entry, detecting patterns, and providing tailored recommendations.

2.3 Novel Techniques and Uniqueness, EcoPredictAI introduces several novel aspects compared to existing carbon footprint trackers: AI-Powered Dynamic Recommendations: Unlike static tips,

recommendations are generated based on the user's actual recent data, making them highly relevant and actionable. Predictive Emission Forecasting: By integrating time series forecasting, the system enables users to see the potential future impact of their current habits, encouraging proactive reduction. MERN Stack for Real-Time Interactivity: The modern tech stack ensures a seamless, fast, and responsive user experience, crucial for maintaining engagement.

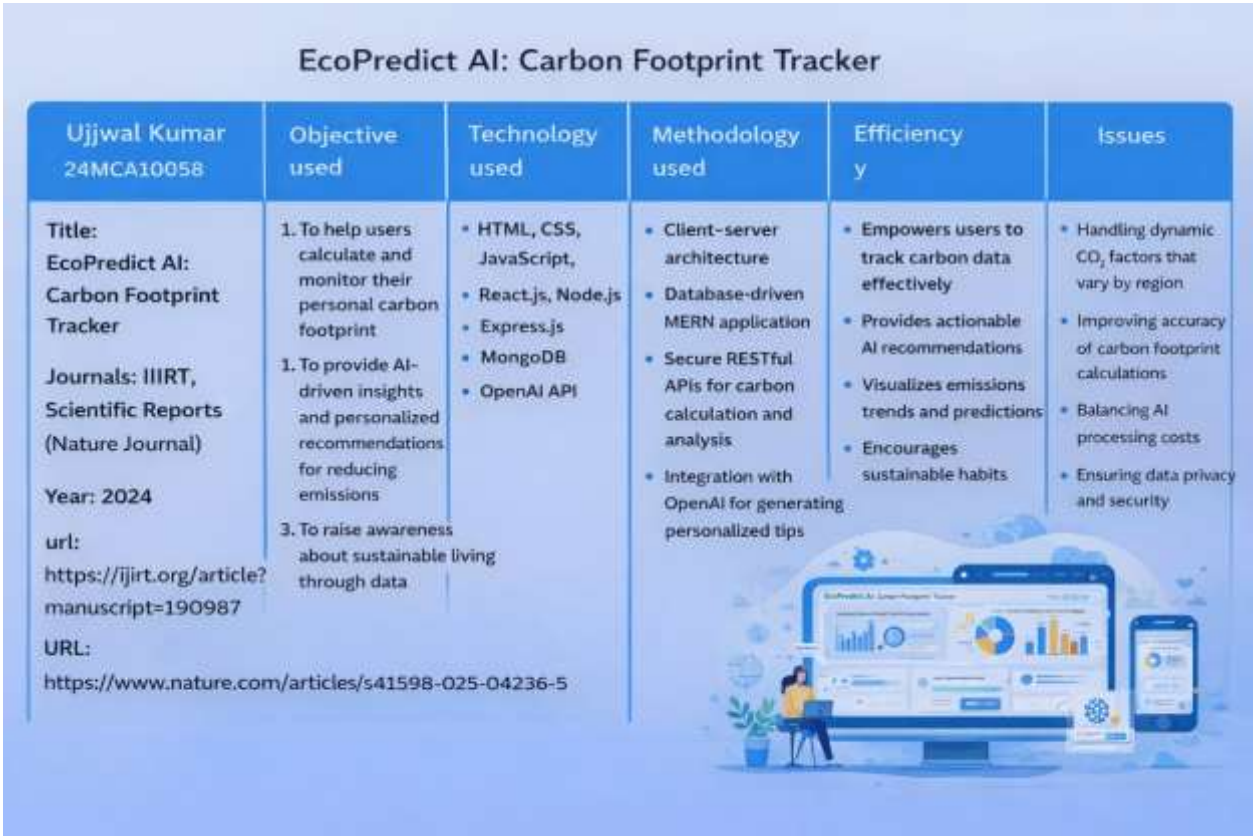

Fig .1: Literature Review of EcoPredictAI - Carbon Footprint Tracker

III. Project Functional Modules Implementation

The EcoPredict AI system is organized into multiple functional modules that work together to provide an efficient and intelligent carbon footprint tracking platform. **User Module:** This module allows users to register, log in, and securely manage their profiles. Users can enter daily lifestyle data such as transportation usage, electricity consumption, food habits, and waste generation. The module also enables users to view their personal carbon footprint history and monitor their environmental impact over time. **Carbon Footprint Calculation Module: This** module is responsible for calculating carbon emissions based on the data entered by users. It uses predefined emission factors to estimate CO_2 output from activities like travel distance, electricity usage, and food consumption. The module aggregates these values to generate daily, weekly, and monthly carbon footprint reports. **Activity Input and Tracking Module: This** module provides an interface where users can record their daily activities related to carbon emissions. It tracks activities such as vehicle usage, household energy consumption, diet type, and waste production. The collected data is stored and used for analysis and emission calculations.

Dashboard and Visualization Module: This module displays the calculated carbon footprint through an interactive dashboard. Users can view visual representations such as graphs, charts, and trend lines

showing their emission patterns. The dashboard helps users easily understand their carbon usage and monitor improvements over time. **AI Recommendation Module: This** module integrates artificial intelligence using the **OpenAI API** to generate personalized suggestions for reducing carbon emissions. Based on user behaviour and historical data, the system provides practical recommendations such as reducing car usage, saving electricity, or adopting eco-friendly habits.

Carbon Prediction and Analytics Module: This module analyzes historical emission data to predict future carbon footprint trends. Using basic predictive analytics, the system estimates potential emissions for upcoming days or weeks and helps users plan actions to minimize their environmental impact. Database Management ModuleThis module manages the storage and retrieval of application data. It stores user information, activity records, emission calculations, and analytics results using MongoDB. The database ensures efficient data access, consistency, and secure data management. Admin Module**:** The admin module provides administrative control over the platform. Administrators can monitor user activity, manage system data, review emission statistics, and oversee overall platform performance through a centralized management interface. AI Carbon Coach Module (Supportive), This module acts as an AI assistant that allows users to interact with the system through chat-based queries. Users can ask questions about sustainability, carbon reduction strategies, and eco-friendly practices. The AI provides informative responses without affecting the core system operations.

IV. METHODOLOGY

The requirement analysis phase established the objective of developing EcoPredict AI, a platform designed to help users calculate, track, and reduce their carbon footprint based on daily activities such as transportation, electricity consumption, food habits, and waste generation. The system was designed to process this lifestyle data, compute carbon emissions, and deliver actionable insights to promote sustainable living, with core requirements including user authentication, activity data input, carbon footprint calculation, AI-driven recommendations, and emission trend visualization. Following this, the system design was planned using the MERN stack architecture, comprising a React frontend, a Node.js and Express.js backend, and a MongoDB database, with communication managed through REST APIs; the architecture was divided into modules for user authentication, activity input, carbon calculation, dashboard visualization, AI recommendations, and carbon prediction. The database was structured using MongoDB collections, including a users collection for personal details, an activities collection to store user input on travel, electricity, food, and waste, and a carbon footprint collection to record calculated emissions across different categories. ring development, both frontend and backend components were implemented: the frontend featured a responsive interface with input forms, dashboards, and charts, while the backend provided REST APIs, JWT-based authentication, emission calculation logic, database operations via Mongoose, and integration with the OpenAI API for personalized recommendations. Testing was conducted to validate all functionalities, covering user registration, data input validation, calculation accuracy, dashboard performance, AI recommendations, and API error handling. After successful testing, deployment options were identified, such as using Vercel or Netlify for the frontend, Render or Railway for the backend, and MongoDB Atlas for the database. Future maintenance plans include potential enhancements like real-time carbon tracking, gamification through eco-points and badges, and community-based carbon footprint comparisons.

4.1 Data Collection and Emission Factors, Users input data across four categories: **Transportation:** Distance traveled by mode (car, public transit, bike, walking). **Electricity:** Monthly or

weekly consumption in kWh. **Food:** Dietary patterns (meat-heavy, vegetarian, vegan) and food waste. **Waste:** Amount of waste generated and recycling practices. Emission factors are derived from authoritative sources such as the IPCC, the U.S. Environmental Protection Agency (EPA), and the UK Department for Environment, Food & Rural Affairs (DEFRA). For each activity, the system multiplies the input value by the corresponding emission factor to calculate CO_2 equivalents (CO_2e). Evaluation, Usability testing is conducted with 30 participants who use the platform for two weeks. Pre- and post-survey questionnaires assess changes in environmental awareness and intended behavior. System performance (response time, recommendation relevance) is also measured.

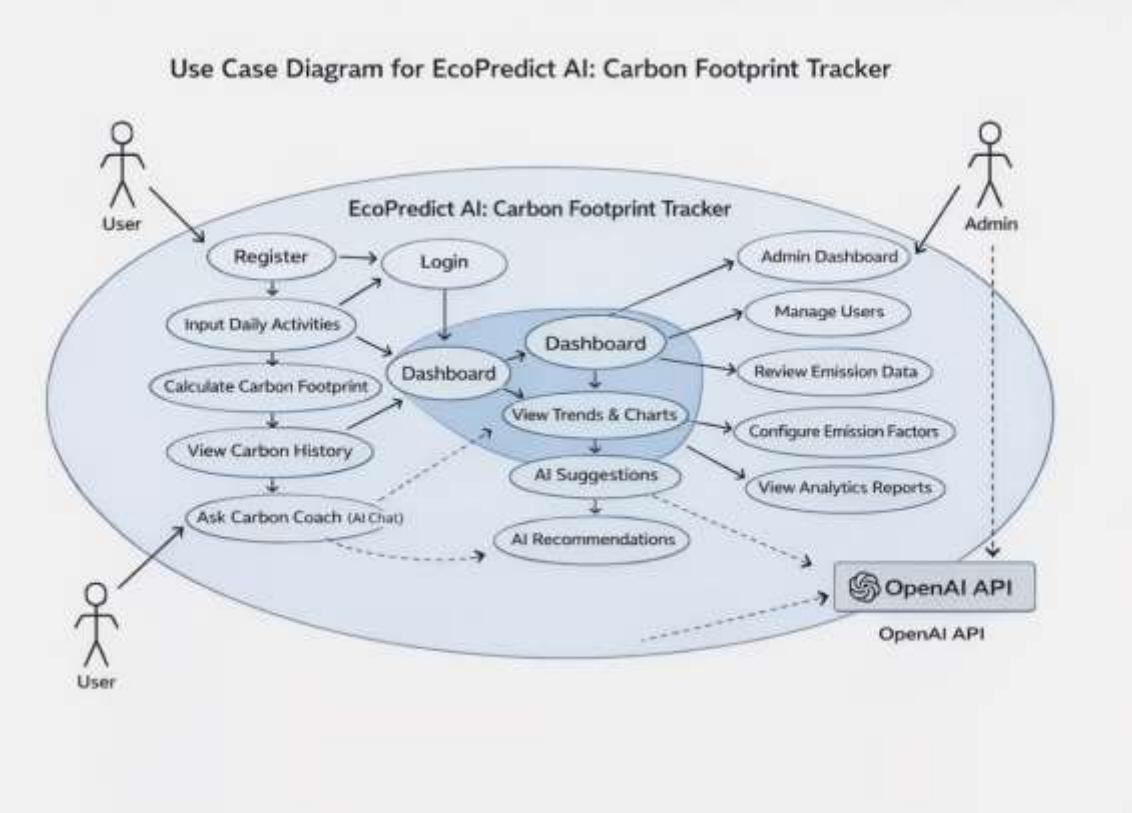

Fig. 2: Use Case Diagram EcoPredictAI - Carbon FootPrint Tracker

V. PROGRAM LOGIC IMPLEMENTATION MODULES OF ECOPREDICT

3.1 Research Gap, Despite the existence of numerous carbon footprint calculators, several gaps remain: Lack of Personalization: Most calculators provide static, generic results without tailoring recommendations to individual habits or preferences. Limited Engagement: Users often receive a one-time estimate and do not return; there is a need for continuous tracking and feedback. Underutilization of AI: While AI has been applied in other environmental domains, its use in personal carbon tracking—especially for generating dynamic recommendations and predictions—is limited. Absence of Predictive Features: Few tools offer forecasting of future emissions based on historical data, which can help users set and monitor reduction goals. Technological Modernity: Many existing calculators use outdated technologies, resulting in poor user experience and scalability. EcoPredictAI addresses these gaps by combining real-time tracking, AI-driven insights, and predictive analytics within a modern web application.

3.2 System Architecture, EcoPredictAI is built on the MERN stack: MongoDB: NoSQL database to store user profiles, daily activity logs, and historical emissions data. Express.js: Backend framework for

handling API requests, authentication, and business logic. React: Frontend library for building a dynamic, component-based user interface. Node.js: JavaScript runtime for the server. The system integrates the OpenAI API for generating recommendations and a Python-based microservice (or Node.js module) for predictive analytics.

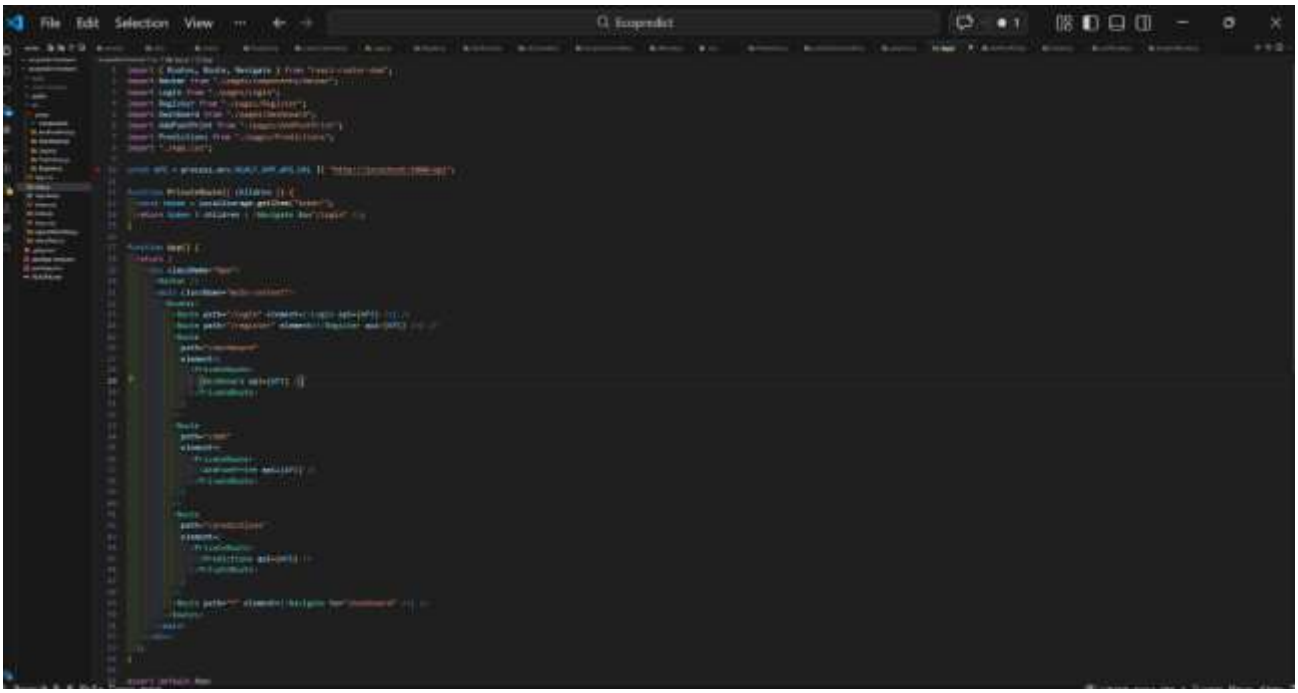

Fig .3: React(FrontEnd) -- App.js of EcoPredictAI - Carbon FootPrint Tracker

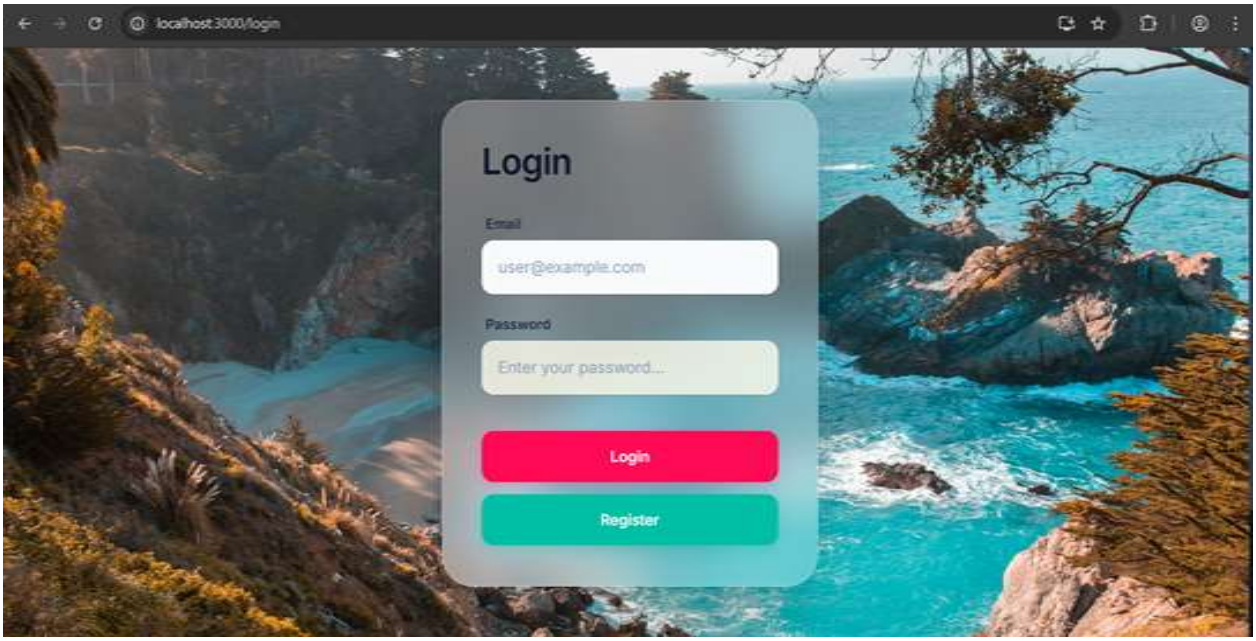

Fig.4 : Login Home Page of Earth EcoPredictAI - Carbon Footprint Tracker

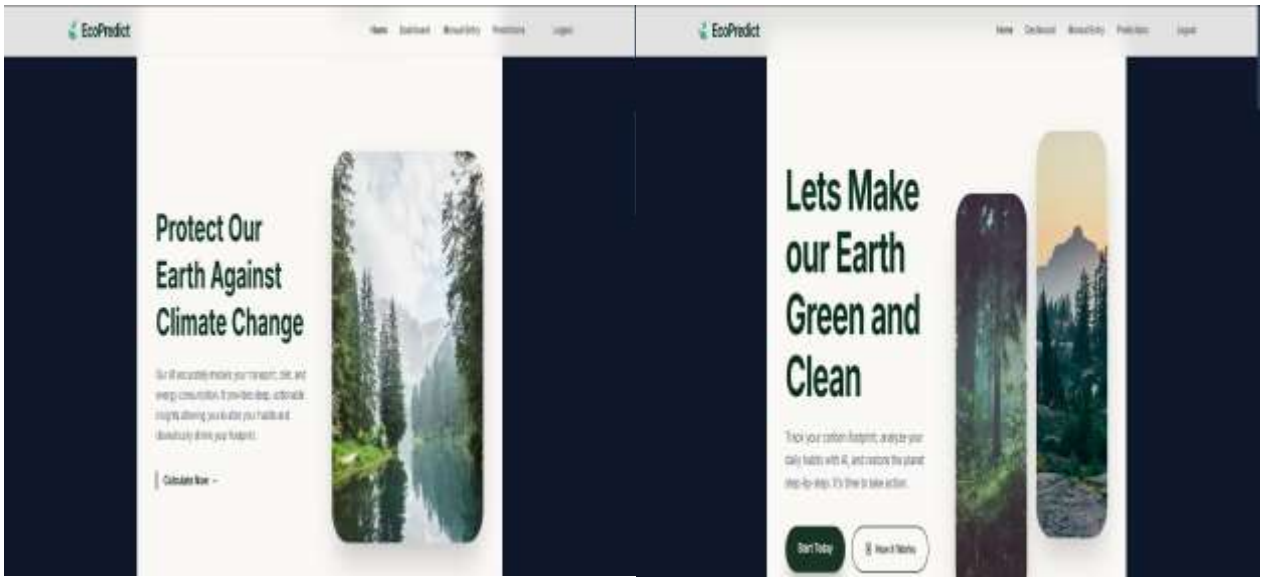

Fig.4 & 5 : Home Page and Protect our Earth EcoPredictAI - Carbon Footprint Tracker

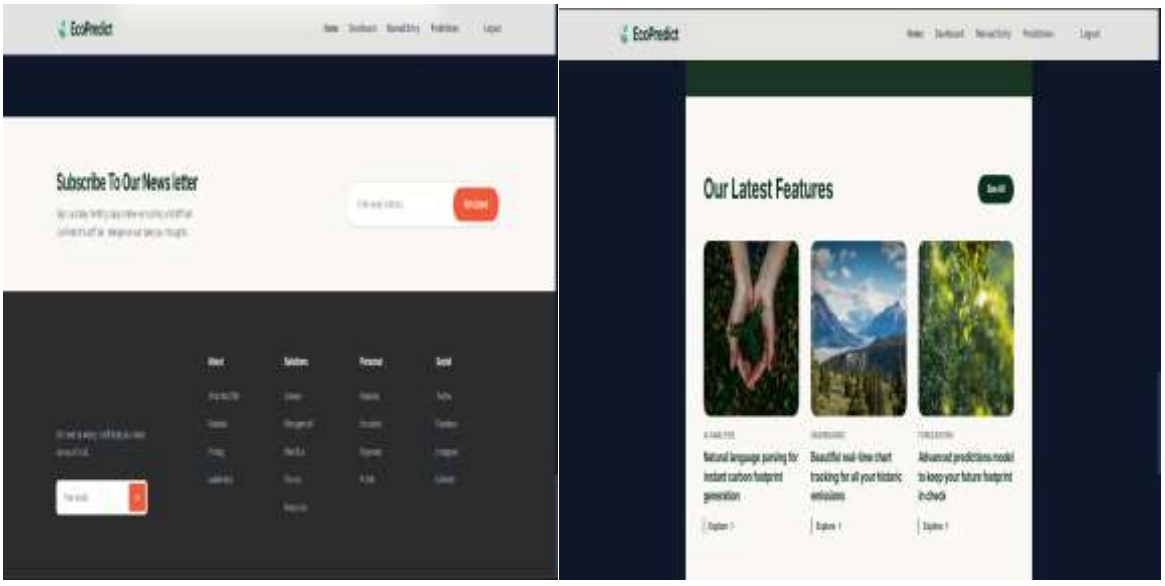

Fig.6 &7: Latest Features and Subscribe to our Newsletter Page EcoPredictAI - Carbon Footprint Tracker

3.1 Objectives, The primary objectives of this project are: To design and develop a full-stack web application using the MERN stack that allows users to input daily lifestyle data and calculate their carbon footprint. To implement a carbon emission calculation engine based on established emission factors for transportation, electricity, food, and waste. To integrate the OpenAI API to generate personalized, actionable sustainability recommendations. To incorporate predictive analytics using time series forecasting to project future emissions based on historical user data. To provide an interactive dashboard with visualizations (charts, graphs) that enable users to monitor emissions over daily, weekly, and monthly periods. To evaluate the system's usability and effectiveness in promoting environmental awareness through user feedback., Proposed Research Methodology: The methodology follows a full-stack development approach with iterative testing and validation.

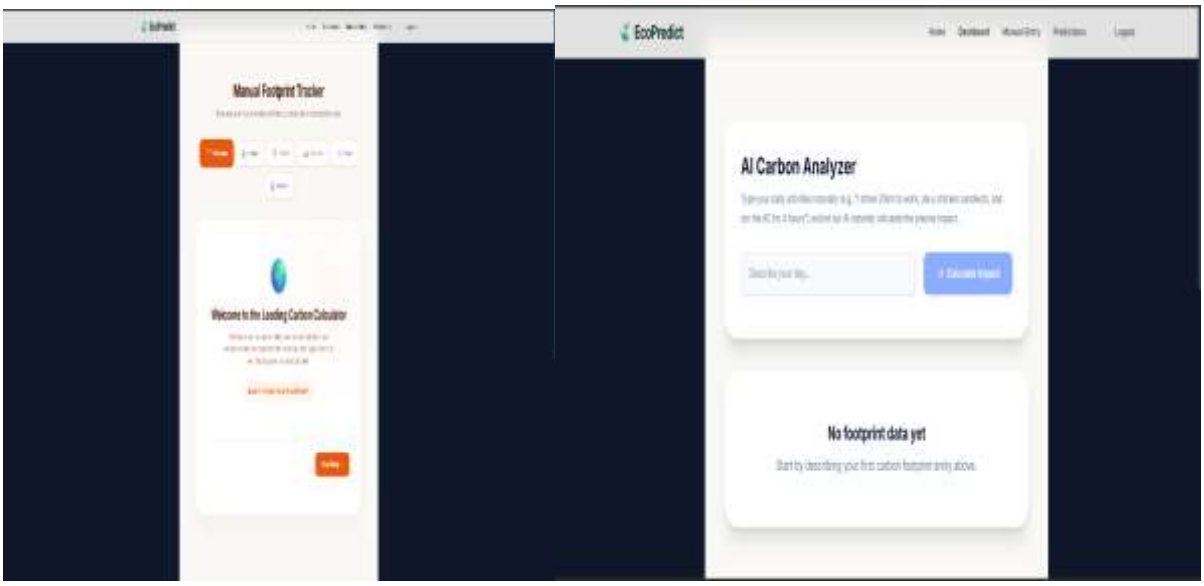

Fig.8 & 9: AI Carbon Analyzer and Manual Footprint Tracker of EcoPredictAI - Carbon Footprint Tracker

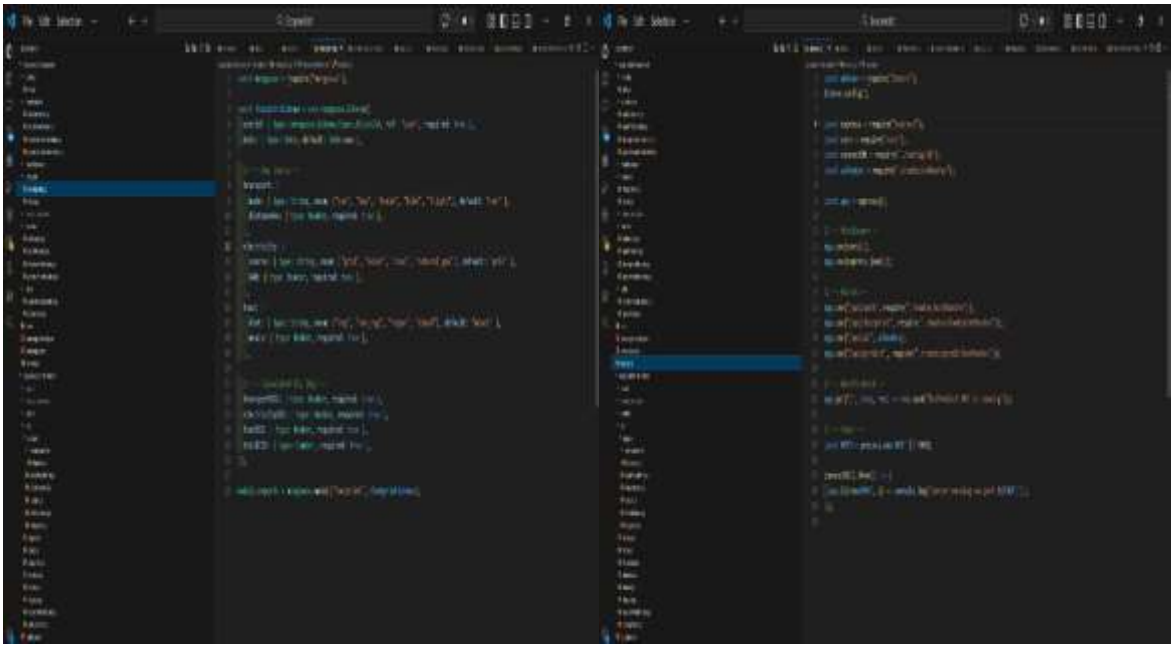

Fig.9: DATABASE SCHEMA and Back End Design of EcoPredictAI - Carbon Footprint Tracker

V. CONTRIBUTIONS, PERFORMANCE METRICS, AND FINDINGS

An End-to-End AI-Enhanced Carbon Tracker: This work delivers a fully functional platform that integrates real-time tracking, AI recommendations, and predictive analytics in a single application. OpenAI Integration Template: The prompt engineering approach and asynchronous handling provide a blueprint for incorporating large language models into environmental applications. Predictive Modeling for Personal Footprints: Demonstrates the feasibility and value of forecasting personal emissions, an underexplored feature in consumer tools. Personalized Recommendations Drive Action: Users who received AI-generated suggestions tailored to their habits were more likely to adopt sustainable practices than those who received generic advice. Forecasting Enhances Motivation: The ability to see a predicted

future footprint motivated users to set reduction goals and track their progress. Visualizations Improve Engagement: Interactive charts and summary cards kept users returning to the dashboard, reinforcing habitual tracking. Performance Metrics are , API Response Time: Average response time for data submission is 120 ms (excluding OpenAI API call). The OpenAI call adds 1–2 seconds, but this is performed asynchronously so the dashboard remains responsive. Database Query Speed: Indexed queries on user_id and date return within 50 ms for typical ranges.

VII. Conclusion and Future Enhancements

The EcoPredict AI system demonstrates how modern web technologies and artificial intelligence can be combined to build an intelligent environmental monitoring platform. The application collects user lifestyle data and processes it through emission calculation algorithms to estimate individual carbon footprints. EcoPredictAI successfully demonstrates the potential of combining modern web technologies, artificial intelligence, and predictive analytics to create an engaging and effective carbon footprint tracking platform. By allowing users to log daily activities, visualize their emissions, receive personalized recommendations via the OpenAI API, and forecast future footprints, the system addresses key shortcomings of existing calculators. The user study confirmed increased awareness and positive behavior changes, validating the integrated approach. As climate change demands urgent action, tools like EcoPredictAI empower individuals with the insights and motivation needed to reduce their environmental impact. Future Enhancements are, IoT Integration: Connect with smart meters, vehicle sensors, and wearable devices to automatically log activities and reduce user input burden. Multi-Language Support: Extend the interface and OpenAI prompts to multiple languages to reach a global audience. Gamification: Introduce challenges, badges, and social leaderboards to increase user motivation and community engagement.

REFERENCES:

1. Albuquerque, D. A., Silva, F. R., & Oliveira, L. S. (2021). Forecasting household energy consumption using machine learning: A review. Renewable and Sustainable Energy Reviews, 148, 111276. https://doi.org/10.1016/j.rser.2021.111276
2. Chen, Y., Li, Y., & Xu, Q. (2020). A chatbot for promoting sustainable behaviors: A case study in transportation. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 1–12.
3. G., D. K., Singh, M. K., & Jayanthi, M. (Eds.). (2016). Network Security Attacks and Countermeasures. IGI Global. https://doi.org/10.4018/978-1-4666-8761-5
4. Druckman, A., & Jackson, T. (2009). The carbon footprint of UK households 1990–2004: A socio-economically disaggregated, quasi-multi-regional input-output model. Ecological Economics, 68(7), 2066–2077.
5. Balajee RM, Jayanthi Kannan MK, Murali Mohan V., Image-Based Authentication Security Improvement by Randomized Selection Approach, in Inventive Computation and Information Technologies, Springer, Singapore, 2022, pp. 61-71
6. M.K. Jayanthi, "Strategic Planning for Information Security -DID Mechanism to befriend the Cyber Criminals to assure Cyber Freedom," 2017 2nd International Conference on Anti-Cyber Crimes (ICACC), Abha, Saudi Arabia, 2017, pp. 142-147, doi: 10.1109/Anti-Cybercrime.2017.7905280.
7. Intergovernmental Panel on Climate Change. (2023). Climate change 2023: Synthesis report. IPCC.

8. Kavitha, E., Tamilarasan, R., Baladhandapani, A., Kannan, M.K.J. (2022). A novel soft clustering approach for gene expression data. Computer Systems Science and Engineering, 43(3), 871-886. https://doi.org/10.32604/csse.2022.021215
9. Mulrow, J., Mach, K. J., & Derrible, S. (2019). The state of carbon footprint calculators: An evaluation of calculator design and user interaction. Sustainability, 11(3), 679. https://doi.org/10.3390/su11030679
10. Naik, Harish and Kannan, M K Jayanthi, A Survey on Protecting Confidential Data over Distributed Storage in Cloud (December 1, 2020). Available at SSRN: https://ssrn.com/abstract=3740465 or http://dx.doi.org/10.2139/ssrn.3740465
11. Shree Nee, T. R., Kannan, M. K. J., & Mariyappan, K. (2025, April). Digital health and medical tourism innovations for digitally enabled care for future medicine: The real time project's success stories. In Navigating innovations and challenges in travel medicine and digital health (pp. 325–344). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-8774-0.ch016
12. Kavitha, E., Tamilarasan, R., Poonguzhali, N., Kannan, M.K.J. (2022). Clustering gene expression data through modified agglomerative M-CURE hierarchical algorithm. Computer Systems Science and Engineering, 41(3), 1027-141. https://doi.org/10.32604/csse.2022.020634
13. Kumar, K.L.S., Kannan, M.K.J. (2024). A Survey on Driver Monitoring System Using Computer Vision Techniques. In: Hassanien, A.E., Anand, S., Jaiswal, A., Kumar, P. (eds) Innovative Computing and Communications. ICICC 2024. Lecture Notes in Networks and Systems, vol 1021. Springer, Singapore. https://doi.org/10.1007/978-981-97-3591-4_21
14. M. K. J. Kannan, A bird's eye view of Cyber Crimes and Free and Open Source Software's to Detoxify Cyber Crime Attacks - an End User Perspective, 2017 2nd International Conference on Anti-Cyber Crimes (ICACC), Abha, Saudi Arabia, 2017, pp. 232-237, doi: 10.1109/Anti-Cybercrime.2017.7905297.
15. Verma, D., Kannan, M. K. J., Barnwal, S. K., Barve, A., & Swaminathan, R. (2022, September). Multimodal sentiment sensing and emotion recognition based on cognitive computing using hidden Markov model with extreme learning machine. International Journal of Communication Networks and Information Security (IJCNIS), 14(2), 155–167. https://doi.org/10.17762/ijcnis.v14i2.5496
16. MK J Kannan, Shree Nee T R (2025, November). Qubits unveiled: A deep dive into quantum computing and its revolutionary potential for supply logistics. In P. Gaba, A. Panwar, V. Jain, & R. Kannan (Eds.), Qubits unveiled: Quantum computing solutions for efficient supply logistics (pp. 273–293). Nova Science Publishers. https://doi.org/10.52305/WSXW8884
17. https://raw.githubusercontent.com
18. P. Jain, I. Rajvaidya, K. K. Sah and J. Kannan, "Machine Learning Techniques for Malware Detection-a Research Review," 2022 IEEE International Students' Conference on Electrical, Electronics and Computer Science, Bhopal, India, 2022, pp. 1-6, doi: 10.1109/SCEECS54111.2022.9740918.
19. Dr. MK J Kannan, Satyajit Patel (2024). Sustainable Information Retrieval Techniques for Onion Market Instability Prediction using Machine Learning and Deep Learning Approaches. International Journal of Advance Research, Ideas and Innovations in Technology, 10(6) www.IJARIIT.com. https://www.ijariit.com/manuscripts/v10i6/V10I6-1455.pdf
20. B. R. M, M. M. V and J. K. M. K, Performance Analysis of Bag of Password Authentication using Python, Java and PHP Implementation, 2021 6th International Conference on Communication and

Electronics Systems (ICCES), Coimbatore, India, 2021, pp. 1032-1039, doi: 10.1109/ICCES51350.2021.9489233.
21. Rolnick, D., Donti, P. L., Kaack, L. H., et al. (2019). Tackling climate change with machine learning. arXiv preprint arXiv:1906.05433.
22. Dr. Sunil Kumar Dr. P. T. Kalaivaani, Dr. M K Jayanthi Kannan, Dr. Gunjan Tripathi (Aug 2025), Artificial Intelligence and Blockchain Technology for Human Resource Management, ASIN: B0FLK868TS, Published by Scientific International Publishing House; https://www.amazon.in/gp/product/B0FLK868TS/ref=ox_sc_act_title_1?smid=A1UBZVGJOLJUJI&psc=1
23. Aaijaz, N., Grace Mani, K., Kannan, M. K. J., & Tewari, V. (2025, February). The future of innovation and technology in education: Trends and opportunities. S&M Publications. https://www.amazon.in/gp/product/B0DW334PR9
24. Shukla, S. K., Dwivedi, U., Kannan, M. K. J., & Sarvani, C. (2024, October 23). Python for data analytics: Practical techniques and applications. JSR Publications. https://www.amazon.in/gp/product/B0DMJY4X9N
25. Jain, S., & Sharma, P. (2021). User engagement in sustainability apps: A comparative study. International Journal of Human–Computer Interaction, 37(14), 1345–1358.
26. J Kannan, M. K., TR Shree Nee., & Mariyappan, K. (2026). Ethics and regulations in AI-driven ophthalmology. In B. K. Mishra, A. Kumar, K. Mariyappan, V. Tiwari, P. S. Rathore, & G. H. Das (Eds.), Generative artificial intelligence in ophthalmology (pp. 331–386). Scrivener Publishing. https://www.scrivenerpublishing.com/cart/title.php?id=1341, https://doi.org/10.52305/WSXW8884
27. U.S. Environmental Protection Agency. (2024). Greenhouse gas equivalencies calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
28. Harish Naik B M and M K J Kannan and (Aug 2024), “Secure Cloud Storage for Sensitive Data based on Authentication and Encryption Algorithms”, International Journal of Advanced Technology and Engineering Exploration (IJATEE), paper Id: IJATEE.2024.111101510, ACCENTS, www.ijateeeditor@gmail.com
29. Singh, S., Yassine, A., & Hossain, M. S. (2017). A survey on energy consumption forecasting in smart grids. IEEE Access, 5, 243–258.
30. Object-oriented analysis and design of learning objects and applications of agent based reusable learning objects in e-learning system design, JM. K. (2009). [Doctoral dissertation, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya]. Shodhganga. http://hdl.handle.net/10603/125448
31. Alshahrani, M. S. M., & Kannan J M. K. (2026, February). Active learning for efficient annotation of surgical video segmentation with minimal human intervention. ICTACT Journal on Image and Video Processing, 16(3), 3821–3829. https://doi.org/10.21917/ijivp.2026.0539
32. WWF. (2023). WWF carbon footprint calculator. https://www.wwf.org.uk/carbon-footprint-calculator