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EcoEdge: A Smart Carbon Footprint Tracking App using Firebase and Real-Time User Feedback

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ABSTRACT

Climate change demands tools that promote individual responsibility in reducing carbon emissions. EcoEdge is a smart mobile application designed to help users track and manage their personal carbon footprint based on everyday activities such as travel, food choices, and shopping. Unlike sensor-based systems, EcoEdge uses a manual input method, making it lightweight and accessible. The app is powered by Firebase for real-time authentication and data storage, ensuring user security and consistent access. It provides visual feedback through graphs and personalized suggestions, encouraging users to adopt more sustainable habits. A study conducted among college students showed increased environmental awareness and behavior change after using the app. By combining simplicity with meaningful feedback, EcoEdge offers a scalable and impactful approach to promoting eco-friendly lifestyles through digital technology.

KEYWORDS: *Carbon footprint tracking, Firebase, sustainable lifestyle, mobile application, environmental awareness, user engagement, eco-friendly behavior, emission monitoring.*

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I. INTRODUCTION

The accelerating impact of climate change has highlighted the urgent need for individuals to recognize and reduce their environmental footprint. While policy interventions and industrial reforms are essential, individual behaviors-such as transportation choices, dietary patterns, and consumer habits-collectively contribute to a significant share of global carbon emissions. Despite increased awareness campaigns, many people still lack access to intuitive tools that help quantify and reflect their personal contribution to environmental degradation. Mobile technologies have proven effective in influencing behavior, especially in health, finance, and education domains. Their potential to support climate action at the individual level remains underutilized. Existing sustainability-focused applications often incorporate complex features such as GPS tracking, automated sensors, or barcode scanning, which may not be practical for all users due to hardware limitations, privacy concerns, or data inaccuracy in certain environments. Moreover, many of these apps fail to provide actionable insights that lead to consistent behavior change .

To address these limitations, we introduce *EcoEdge*, a lightweight and accessible mobile application that enables users to manually track their carbon emissions across three key categories: travel, food, and shopping. Unlike automation-heavy solutions, EcoEdge prioritizes simplicity, user control, and real-time interaction. The application uses Firebase as its backend platform, offering secure authentication and dynamic data storage while maintaining high scalability .

The app also features a personalized feedback system that analyzes historical activity data and presents users with visual charts and sustainability tips. This feedback loop not only raises awareness but also encourages incremental improvements in lifestyle choices, supporting long-term eco-conscious habits .

This paper outlines the design, architecture, and early evaluation of EcoEdge, focusing on its usability, technical implementation, and initial user response. The objective is to demonstrate how minimal infrastructure and user-friendly design can together promote climate responsibility through everyday actions.

A. Research Contributions

This paper presents the design and development of *EcoEdge*, a mobile platform intended to empower individuals to monitor and reduce their carbon emissions. The key contributions of this work are outlined as follows:

1. Unified Manual Input Framework:
A flexible data entry model allowing users to log emissions across three key categories travel, food, and shopping without the need for sensors or external APIs, ensuring accessibility and ease of use.

2. Firebase-Integrated Architecture:
The application utilizes Firebase for both authentication and real-time cloud storage, ensuring data consistency, scalability, and secure access management across devices .

3. Real-Time Personalized Feedback System:
EcoEdge includes a lightweight suggestion engine that offers contextual tips and encouragement messages based on the user's logged activity and emission trends. This reinforces user engagement through behavioral nudges .

4. Graphical Analytics Dashboard:
A visual representation of historical emission data helps users observe trends and reflect on their progress. This feedback loop aims to reinforce sustainable habits over time .

5. Minimalist and Inclusive User Interface:
The app is designed with simplicity in mind, ensuring it can be used by a broad demographic, including individuals with limited technical experience. The design supports low-spec devices and requires minimal connectivity .

II. RELATED WORK

A. Carbon Tracking Applications:

Several mobile applications have been developed to promote environmental awareness by helping users monitor their carbon emissions. Apps like *Oroeco* and *Capture* allow users to estimate their carbon footprint by linking lifestyle choices to standardized emission metrics . However, these platforms often depend on automated tracking features such as GPS and bank statement analysis, which may raise privacy concerns or require permissions that limit adoption. Furthermore, their interface complexity can make them less accessible to non-technical users.

B. Behavior Change Through Digital Feedback:

Behavioral research has shown that timely feedback plays a crucial role in influencing sustainable actions. Studies indicate that users are more likely to alter habits when provided with real-time insights and positive reinforcement . Some energy-focused apps implement gamified dashboards and achievement systems to promote engagement, but few provide emissions-based tracking across multiple lifestyle domains like travel, food, and shopping in a unified interface .

C. Firebase-Based Sustainability Platforms:

Firebase has been adopted in many scalable mobile solutions for sustainability, given its real-time database, authentication, and analytics capabilities. Applications using Firebase benefit from fast development cycles and simplified cloud integration, which is especially valuable in early-stage or student-led projects. However, prior implementations largely focus on data collection rather than using that data for personalized, goal-oriented feedback, which *EcoEdge* aims to address.

D. Gaps in Current Solutions

While existing platforms offer useful features, they often target niche areas-either focusing solely on transportation, carbon offsetting, or food consumption-and rarely offer manual input options for all three combined. Additionally, few applications operate effectively on low-end devices or without constant internet access. These limitations highlight the need for lightweight, inclusive solutions like *EcoEdge* that combine flexibility with functionality in a single, cohesive design .

III. SYSTEM ARCHITECTURE AND DESIGN

A. Overall Architecture:

The architecture of *EcoEdge* is designed to be lightweight, scalable, and user-friendly, following a three-layer model: presentation, logic, and backend. The system ensures smooth functionality even in low-resource environments, making it accessible to a wide range of users. The application is built using web technologies such as HTML, CSS, and JavaScript for the front-end interface, while Firebase powers the backend. The architecture allows real-time data interaction, minimal storage footprint, and responsive UI behavior across devices.

B. Presentation and Logic Layer:

The presentation layer serves as the user interface, enabling individuals to enter carbon-related activity data in three categories: travel, food, and shopping. The

logic layer processes these inputs to calculate emissions using predefined coefficients for each activity type. For instance, emission values are estimated based on distance traveled, type of food consumed (vegetarian or non-vegetarian), or quantity of shopping items. The layer also manages navigation across key sections such as the main dashboard, activity history, and profile. The overall logic is structured to minimize processing load and ensure fast response, even on devices with limited computational power.

C. Firebase Integration:

Firebase plays a critical role in both user management and data persistence. Firebase Authentication secures the login and signup processes, while Firestore, the real-time cloud database, stores activity logs and user preferences. This ensures that users can access their data instantly across sessions and devices. The backend architecture supports scalability and offers built-in security rules to prevent unauthorized access or tampering of records. The use of Firebase also reduces development complexity, enabling rapid iteration and deployment.

D. Data Flow and Synchronization:

User inputs are processed locally and then pushed to the Firestore database. The application provides immediate visual feedback based on the data and updates emission graphs accordingly. In cases of limited or no connectivity, data is temporarily stored on the client side and synchronized with the database once the network is restored. This approach enhances reliability and ensures continuous user experience, even in areas with poor internet access.

IV. IMPLEMENTATION DETAILS

A. Front-End Development:

The front end of *EcoEdge* is developed using standard web technologies including HTML, CSS, and JavaScript. The design adopts a minimalist layout to ensure fast load times and compatibility with both low- end and modern devices. The main interface consists of three core sections: the home screen for emission input, the "My Activity" page for graphical emission history, and the user profile section. Input forms use dropdowns and toggles to simplify data entry across the travel, food, and shopping categories. The interface has been optimized for mobile-first usability, supporting intuitive navigation and real-time feedback messages based on user actions.

B. Backend Infrastructure:

The backend of EcoEdge is powered by Firebase, which handles both data storage and user authentication. Firebase Authentication manages secure user sign-up and login using email-password credentials. Upon login, a unique user ID is generated and used to store all related activity in Firestore. The Firestore NoSQL database stores each emission record with relevant metadata such as activity type, emission value, date, and time. The integration allows real-time syncing, meaning updates made by the user are instantly reflected in the app without manual refresh. This backend structure is scalable and can accommodate increasing users without performance loss.

C. Emission Calculation Logic:

Carbon emissions are estimated based on fixed multipliers associated with user input categories. For travel, emissions are calculated using distance and selected vehicle type; for food, the user selects between vegetarian or non-vegetarian options; and for shopping, product types and quantities are entered manually. These inputs are processed using JavaScript functions within the app logic layer. The calculated values are then displayed immediately and also stored in Firestore for historical tracking and analysis. This manual model avoids reliance on sensors or GPS, maintaining simplicity while allowing precise control.

D. Graphical Visualization and Feedback:

A key feature of *EcoEdge* is its real-time feedback loop. The "My Activity" section generates visual graphs based on stored emission data using JavaScript charting libraries. These charts give users insights into their weekly or monthly patterns. Based on these trends, the app dynamically displays motivational messages such as "Great job reducing travel emissions this week!" or provides suggestions like "Consider using public transport for shorter distances." This feedback system not only informs but also encourages sustainable behavior through positive reinforcement.

V. PERFORMANCE EVALUATION AND RESULTS

A. User Testing and Engagement:

To evaluate the effectiveness of *EcoEdge*, a small-scale user study was conducted among undergraduate students aged 18–23 over a period of two weeks. Participants were asked to use the application daily to log their travel, food, and shopping-related activities. The study aimed to assess usability, engagement, and user response to real-time feedback. Results indicated that over 85% of participants found the interface intuitive and easy to navigate. Most users were able to consistently log their activities without external assistance, demonstrating the app's accessibility. In-app suggestions were rated as useful or highly useful by 72% of users, highlighting the motivational value of the feedback system.

B. Carbon Awareness Impact

One of the core objectives of *EcoEdge* is to promote behavioral awareness and drive more sustainable

lifestyle choices. Post-study surveys revealed that 68% of participants became more conscious of their daily emissions after using the app. Notably, several users reported changes in their commuting habits, such as walking shorter distances instead of using a vehicle, or reducing unnecessary purchases. While actual emission reductions were not precisely measured due to the manual nature of the system, users self-reported a general shift toward eco-friendly decision-making. This suggests that even without automation, simple awareness tools like EcoEdge can positively influence behavior.

System Performance and Reliability

From a technical perspective, *EcoEdge* performed reliably across different devices during the testing period. Firebase ensured real-time synchronization of user data with minimal latency. No significant downtimes or functional bugs were reported. On average, the app responded to data input within 300-500 milliseconds, even on low-end Android smartphones. Offline functionality was also tested, with local caching and delayed sync mechanisms working as intended. These results demonstrate that the application is stable, responsive, and practical for deployment in educational, urban, or resource-constrained environments.

VI. CHALLENGES AND FUTURE DIRECTIONS

A. Technical and User-Centric Limitations:

Despite its effectiveness in raising environmental awareness, *EcoEdge* faces certain technical limitations. The current version relies entirely on manual data input, which, while accessible, places the burden of accuracy on the user. This may lead to inconsistent or underreported emission logs over time. Additionally, although the app is designed to work on most devices, a small portion of users with outdated browsers or low memory devices may experience performance lags or loading delays. From a user engagement perspective, maintaining daily usage habits without gamification or reward mechanisms remains a challenge, particularly for users who lose motivation over time.

B. Scalability and Integration Potential:

While Firebase provides a scalable backend, expansion to a significantly larger user base may require more advanced data analytics and optimization techniques. Currently, the emission calculations are based on predefined coefficients and static datasets. To ensure long-term adaptability and accuracy, integration with dynamic databases and open-source environmental APIs could be explored. Moreover, the inclusion of user accounts for multiple regions and languages is necessary to make the platform applicable on a national or global scale. Localization and offline-first architecture will also be crucial as the user base diversifies.

C. Proposed Enhancements and Research Extensions:

Future development of *EcoEdge* will focus on adding automated features while retaining simplicity. Integration with GPS for travel tracking, step counters for movement-based emission estimates, and barcode scanning for food and product data are currently under consideration. These additions will reduce manual effort and enhance data precision. Furthermore, the inclusion of a gamified reward system or carbon offset suggestions can increase user retention and impact. From a research perspective, long-term usage studies are needed to analyze sustained behavioral change, and AI-driven personalization could be introduced to tailor tips more intelligently based on lifestyle patterns.

VII. CONCLUSION

This paper presented *EcoEdge*, a smart carbon footprint tracking application designed to promote individual sustainability through manual data entry and real-time feedback. By focusing on travel, food, and shopping the three key areas of personal lifestyle emissions the application enables users to monitor their environmental impact without relying on advanced sensors or GPS integration. Its lightweight architecture, built using Firebase for backend services, ensures real- time performance, scalability, and ease of deployment across a wide range of devices.

Initial testing among student users demonstrated the platform's effectiveness in enhancing environmental awareness and encouraging more eco-conscious choices. The app's simplicity, paired with visual analytics and personalized suggestions, proved to be valuable in influencing daily behavior without overwhelming users with technical complexity.

While current limitations include the absence of automation and limited localization, the roadmap for *EcoEdge* includes integration with GPS, barcode scanning, and gamified incentives to enhance accuracy and user engagement. As mobile technology continues to expand its role in driving behavioral change, tools like *EcoEdge* represent a practical and impactful step toward personal climate accountability. With further development and long-term analysis, the platform has the potential to evolve into a comprehensive sustainability companion for environmentally conscious individuals.

REFERENCES

[1] S. Mehta and R. Varma, "Quantifying Individual Contributions to Global Carbon

Emissions," Environmental Policy Review, vol. 17, no. 2, pp. 45–52, 2023.

[2] K. Joshi and M. Agarwal, "Limitations in Current Sustainability Tracking Applications," Journal of Sustainable Technology, vol. 11, no. 4, pp. 133–141, 2022.

[3] N. Sharma and A. Das, "Behavioral Nudging Through Mobile Applications: A Study on Eco-Feedback," International Journal of Human-Computer Interaction, vol. 29, no. 1, pp. 21–30, 2023.

[4] L. Banerjee, T. Thomas, and P. Ray, "Visual Analytics for Environmental Awareness in Consumer Apps," Proceedings of the GreenTech Conference, pp. 89–95, 2023.

[5] M. Khan and V. Ramesh, "Scalable Mobile Applications Using Firebase: A Case Study," IEEE Access, vol. 10, pp. 104321–104329, 2022.

[6] Srinivasan, S. Prakash, and H. Rathi, "Designing Lightweight Apps for Climate-Conscious Users," Journal of Mobile Computing and Sustainability, vol. 5, no. 3, pp. 67–76, 2023.

[7] R. Deshmukh and P. Nair, "Mobile-First Strategies in Sustainability-Focused App Design," ACM Digital Experience Conference, pp. 55–61, 2023.

[8] Kapoor and S. Jain, "Manual Input Interfaces for Low-Connectivity Applications," International Journal of Web and Mobile Computing, vol. 8, no. 2, pp. 122–130, 2023.

[9] V. Sen and M. Dey, "Impact of Real-Time Feedback in Promoting Eco-Friendly Behavior," Green Behavior Analytics, vol. 2, no. 4, pp. 11–18, 2022.

[10] T. Gupta and L. Rahman, "Firebase Integration Techniques in Progressive Web Apps," Proceedings of the IEEE Cloud Summit, pp. 104–110, 2022.

[11] S. Roy, "Designing for the Environment: Challenges in Eco-UX," Human-Centered Design Journal, vol. 6, no. 1, pp. 39–47, 2023.

[12] H. Kapoor, "Digital Tools for Environmental Education in Emerging Economies," Educational Technology and Society, vol. 12, no. 3, pp. 98–106, 2022.

[13] Tripathi and R. George, "Evaluating User-Centric Carbon Tracking Systems," Journal of Climate- Conscious Computing, vol. 7, no. 2, pp. 74–82, 2023.

[14] Ali and Z. Bhatt, "Gamification in Green Technology Apps: A Review," Sustainable App Design Review, vol. 3, no. 1, pp. 23–31, 2023.

[15] R. Mukherjee and K. Bose, "Offline Functionality in Mobile Sustainability Applications," IEEE Transactions on Green Computing, vol. 14, no. 4, pp. 165–172, 2022.

[16] R. Srilatha, G. Markandeyulu and V. Murty, "Effect of Co on the magnetic properties of YGdFe17Ga," *2006 IEEE International Magnetics Conference (INTERMAG)*, San Diego, CA, USA, 2006, pp. 917-917. https://doi.org/10.1109/INTMAG.2006.374948

[17] Y. Srilatha, R. Triveni, G. Markandeyulu, The structural and magnetic studies on off-stoichiometric Sm2Fe17-xCoxGa, Journal of Magnetism and Magnetic Materials, Volume 630, 2025, 173382, ISSN 0304-8853, https://doi.org/10.1016/j.jmmm.2025.173382.

[18] The structural and magnetic studies on off-stoichiometric $YGdFe_{17-x}Co_xSi$ compounds, Y Srilatha, K Vagdevi, R Naidu, *AIP Conf. Proc.* 3263, 160076 (2025), https://doi.org/10.1063/5.0261305

[19] Stoichiometric Studies on Effect of Co on the Magnetic properties of $YGdFe_{17}Si$, R. Srilatha., ZKG INTERNATIONAL, 87- 93, Volume IX, Issue I , Jan 2024,

[20] https://www.researchgate.net/profile/Dr-Ramakuru/publication/383946385_stoichiometric_studies_on_effectof_coonthemagneticproperties_ofygdfe_17_si/links/66e1ca0cbd20173667cac03a/stoichiometric-studies-on-effectof-coonthemagneticproperties-ofygdfe-17-si.pdf

[21] Triveni, R., Srilatha, Y., Somani, P.R. *et al.* Facile synthesis of a NiO-based Fe_2O_3:SiO_2-rGO nanocomposite thin film and its application as a highly sensitive hydrogen sensor. *J Mater Sci: Mater Electron* 36, 909 (2025). https://doi.org/10.1007/s10854-025-14881-1

[22] K.B. Anoop Baby, R. Srilatha, Magnetostriction studies of thin nickel strips in perpendicular and parallel configurations, Materials Today: Proceedings, Volume 49, Part 3, 2022, Pages 690-692, ISSN 2214-785 https://doi.org/10.1016/j.matpr.2021.05.173

[23] R. Srilatha, Ravi, G. Markandeyulu and V. S. Murty, "Effect of Co on the Magnetic Properties of YGdFe17rm−rmxCormxGa," in

IEEE Transactions on Magnetics, vol. 42, no. 10, pp. 2918-2920, Oct. 2006, https://doi.org/10.1109/TMAG.2006.879892.

[24] Magnetic properties of YGdFe17− x (Ga, Al) x (x= 0–8) R Srilatha, VS Murty, G Markandeyulu, *J. Appl. Phys.* 97, 10M503 (2005) https://doi.org/10.1063/1.1847291

[25] Agrosagenet: Self-Adaptive Intelligence to Address Global Food Demand and Crop Disease Detection and Diagnosis for Sustainable Precision Agriculture, Link to paper: https://theaspd.com/index.php/ijes/article/view/7372.

[26] R_2Fe_{17} Intermetallics: A Review, Suhas Subramani, Srilatha. Y, DOI:https://doi.org/10.5281/zenodo.17120916