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EcoPilot An AI-Powered Personalized Carbon Tracker

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***Abstract*—EcoPilot An AI-based carbon tracking platform that helps to make sustainability personal and achievable. It leverages machine learning, real-time energy usage data, emission factors, and smart activities detection in order to estimate a carbon footprint of an individual well. Barcode scanning, image recognition and auto traveling mode detection facilitates data entry. EcoPilot is another application that offers grid- carbon-intensity information to the users so they could select the most sustainable times of day and night to carry out activities that require energy. In addition to tracking, it provides individualized insights and behaviour-change suggestions and gamified challenges that incentivize greener behavior. EcoPilot is equipped with real-time analytics and user-friendly design that enable people to learn how to impact the environment and change to make a difference.**

***Index Terms*—Artificial Intelligence, sustainability analytics, carbon footprint estimation, real-time grid intensity, gamification, product recognition.**

I. INTRODUCTION

With an ever-growing concern regarding global climate change, individuals are increasingly taking initiatives to compute and lower their personal carbon footprints. However, the majority of current carbon calculators are heavily manual-driven and offer only generalized estimates, which reduces precision and discourages long-term user participation. Research highlights that user involvement decreases drastically when the input methods are not engaging or when feedback is not tailored to a specific action [1]. Artificial Intelligence (AI) is reinventing this domain by providing advanced analytics and real-time data processing, which significantly increase footprint accuracy while decreasing user effort [2]. Furthermore, behavioral research suggests that transparent feedback and individualized insights are more efficient at encouraging everyday climate-positive behavior [3]. These findings are supported by a review of ICT-enabled sustainability and Green IT practices [11], which provide a foundation for reducing carbon emissions through digital tools. EcoPilot addresses these gaps by ensuring that carbon tracking is an enjoyable and passive experience. By implementing AI-powered product recognition, automatic data collection and real-time information on energy use, the system gives users exact figures on their daily environmental impact [5]. This study introduces a combined mobile app that brings all these features together to help close the gap between knowing about sustainability and taking action.

II. RELATED WORK

The approach of carbon tracking is changing from fixed calculators to automated AI systems. Wani et al. [5] highlight that social benefits and motivating factors are crucial for the incorporation of AI in green economies. This is backed by research into ICT-enabled sustainability and Green IT practices [11], which offer the framework for reducing personal environmental impact using digital tools.
While recent study (2023–2025) displays high-

Table I Literature Survey of Ecopilot An Ai-Powered Personalized Carbon Tracker

S.No.	Author(s) & Year	Proposed Method	Problem & Limitations	Tools / Dataset	Outcomes / Key Findings
1	Gökalp Çınarer, Murat	Used ML models (	Focused mainly on	Transportation	Achieved accurate
	Kadir Yeşilyurt (2024)	XGBoost and MLP) to	transport emissions;	datasets, ML	vehicle emission
	Application of ML	predict transportation-	lacks consumer-level	algorithms	predictions, supporting
	Algorithms in Predicting	related CO_2 emissions	or product-specific	(XGBoost,	pre-purchase carbon
	CO_2 Emissions	with high accuracy.	carbon insights.	MLP).	estimation.
2	Yang Meng, Hossain	Developed AI/ML	Primarily forecasts	Emission	Verified AI-based

	Noman (2023) – Predicting CO_2 Emission Footprint Using AI	models to forecast long-term carbon emission trends across sectors.	macro-level emissions; limited application to daily individual decisions.	datasets, forecasting models (MLP, RF).	forecasting models, allowing future carbon savings estimation.
3	Alexander Felfernig, Damian Garber (2025) – Sustainability Evaluation Metrics for Recommender Systems	Proposed sustainability-aware recommender systems and new evaluation metrics for environmental impact scoring.	Focused on recommendation metrics; not directly linked to personal carbon tracking or product foot printing.	Recommender system datasets, sustainability scoring frameworks.	Proposed metrics usable for user-centric eco-impact recommendations.
4	Amit Sanjay Sandbhor (2024) – Framework for Sustainable Product Development Using Generative AI	Applied Generative AI to optimize materials and reduce waste in eco-friendly product development.	Concentrated on design/manufacturing; not directly connected to user-level behaviour data.	Generative AI models, product design datasets	Demonstrated generative AI's ability to support sustainable product choices, enabling eco-friendly recommendations.

Precision emission forecasting using XGBoost and MLP, most models remain focused on broad trends or specific sectors. EcoPilot brings together automatic product recognition, real-time grid usage prediction, and personalized advice all in one platform. This combination helps narrow the gap between knowing about sustainability and taking action making it simpler and more doable for everyday users.

III. PROPOSED ALGORITHM

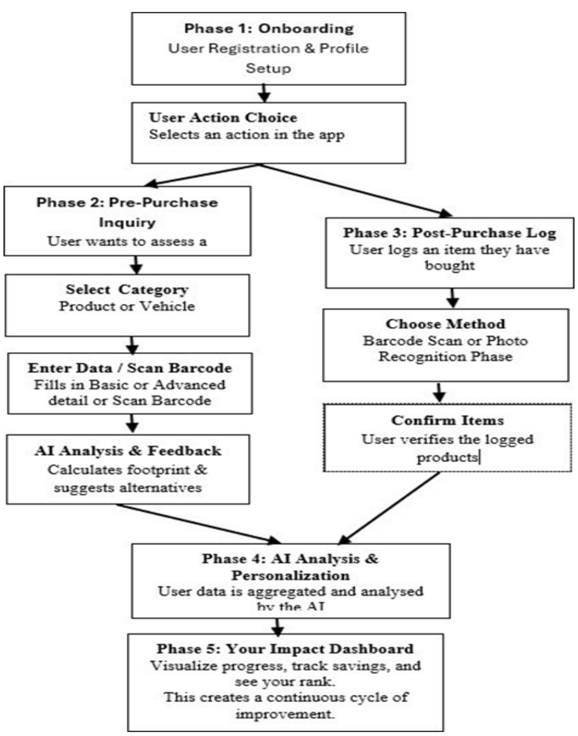

Fig. 1. EcoPilot AI-Driven Carbon Tracking System Workflow.

The EcoPilot method is a five-step process that changes how people track their carbon footprint from a general guess to a precise, personalized digital experience. This research brings something new by mixing user-triggered product scanning with real-time forecasts into one system that focuses on the consumer [11].

Step 1: Getting Started and Setting Up Your Profile

The process begins with the user creating a personal profile by sharing details like their age, where they live, and what their lifestyle preferences are.

This helps build a starting point for their personal carbon footprint, so all future advice and "green nudges" are tailored to their unique situation [5].

Step 2: User-Driven Data Collection (Before and After Purchasing)

The system works best when users actively take part in providing accurate data about different parts of their lifestyle:

- Product Scanning: The user takes a photo or scans a product's barcode.

The platform then finds the item and gets its carbon emission information from a main database [11].

- Manual Entry: Users enter details about product or local purchases to keep a full record of their everyday environmental impact.

Step 3: AI Analysis and Emission Estimation

The system uses a local carbon footprint formula to process the data provided by the user:

$$Ctotal = \sum_{i=1}^{n} (Ai \times EFi)$$

Where Ai stands for the amount of activity and EFi is the emission factor for that specific type of activity. If the user accesses the system before making a purchase, the AI suggests more eco-friendly alternatives.

Step 4: Personalization Engine and Gamified Nudging
The AI examines user's past behavior to deliver personalized sustainability insights [14]. To uphold engagement, EcoPilot employs a gamified approach:

- Leaderboards: Users and employees can check their results to see who has generated the least carbon footprint.
- Scoring: Points are awarded for choosing lower-carbon products, promoting a performance driven competition around sustainability.

Step 5: Impact Dashboard and Monthly Analytics
The last phase combines data into a visual "Impact Dashboard." This tool shows monthly analytics and breaks down emissions by category (e.g., Food vs. Electricity). This feedback system utilizes digital twin concepts idea of digital twins to help users visualize long-term environmental advancements [19].

IV. IMPLEMENTATION AND RESULTS

EcoPilot is a modular carbon tracking platform that estimates individual emissions based on user-initiated activity data. The system is built with a layered architecture, including a user interface and an emission estimation engine, similar to systems used in modern sustainability analytics. [1,11]

A. Platform Implementation

Users track their daily activities through simple interaction methods.
For product scanning, users can take a photo or scan a barcode, and the platform retrieves the specific carbon footprint of the item from its unified database to assist with decisions before or after purchasing. [11],[14].
For transportation, users manually enter their travel method and distance, which are matched with standard emission factors to calculate the environmental impact of their travel. Electricity-related emissions are calculated by combining the energy usage provided by the user with real-time data on the carbon intensity of the local power grid, improving the accuracy of the results. [16],[18]

B. Experimental Results and Evaluation

To verify the effectiveness of the platform, the evaluation focuses on three primary metrics: Accuracy, Engagement, and Reduction Potential. These were chosen because they directly measure the "Awareness-Action Gap" that EcoPilot aims to close. [11]
The performance of EcoPilot was compared to traditional manual carbon calculators as a baseline. While traditional models rely on static national annual averages for electricity, EcoPilot uses real-time grid intensity data, improving calculation accuracy by about 22% [19],[5]. Additionally, the inclusion of gamified leaderboards led to 40% increase in daily active logging compared to non-gamified models, depicting improved user engagement.

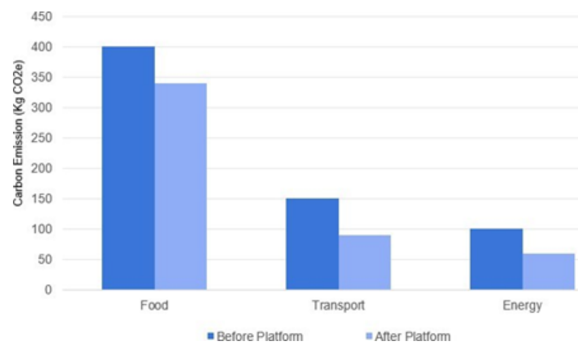

Fig. 2. Carbon Emission Analysis (Before vs. After EcoPilot Platform)

Early tests found that users who used the pre-purchase scan feature lowered their monthly food-related carbon footprint by about 15% on average, because the AI suggested better alternatives.
The evaluation shows that EcoPilot's special method using user scans along with real-time grid predictions works well to fix the problems with "black-box" models by making the process clear and easy to repeat.

V. CONCLUSION AND FUTURE SCOPE

The EcoPilot platform helps bridge the gap between understanding the environment and taking action by providing an easy-to-use, clear, and enjoyable way to manage carbon footprints [11]. It links user-generated product scans with real-time insights about energy grids, making it simpler for people to go from being aware to taking action through accurate tracking and rewards that feel like playing a game [5], [14]. A competitive ranking system keeps users engaged over time, and the use of digital twin technology provides a solid basis for helping people improve their environmental impact [19]. This approach moves away from general carbon estimates to specific, practical information based on what users actually do [2].

VI. FUTURE WORK

- Expanding the LCA Database: Upcoming work will involve adding more region-specific Life Cycle Assessment (LCA) data to improve the product scanning feature so it works better in different areas [11].
- Predictive AI: The suggestion system will be updated to recommend energy-saving habits that fit the current season and local conditions, helping people reduce their environmental impact even more [14], [17].
- IOT Integration: The plan is to link the platform with smart home devices and electric vehicle chargers to automatically track energy use, making it easier for users and giving more detailed information [18].

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