

Intelligent Eco Habit Monitoring and Sustainability Recommendation System using Natural Language Processing

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Abstract - The increasing environmental challenges such as climate change, excessive waste generation, and high carbon emissions highlight the urgent need for sustainable lifestyle practices. However, many individuals lack awareness and personalized guidance to adopt eco-friendly habits effectively.

The proposed project, Intelligent Eco Habit Monitoring and Sustainability Recommendation System using Natural Language Processing, aims to address this issue by developing a smart and interactive platform that monitors user activities and provides personalized sustainability recommendations. This system leverages Natural Language Processing techniques to analyze user inputs, daily activity logs, and textual feedback related to energy consumption, transportation, waste management, and resource usage. The proposed solution integrates with NLP models to enhance recommendation accuracy and adaptability over time. A user-friendly web interface is developed to allow users to input their activities, track sustainability scores, and receive actionable suggestions. The system not only promotes environmental awareness but also empowers individuals to make informed decisions that contribute to long-term ecological balance.

Key Words: Natural Language Processing (NLP), Sustainability, Eco Habit Monitoring, Carbon Footprint Estimation, Environmental Awareness, Sustainability Recommendation System, Text Classification, Smart Web Application, Green Lifestyle, Sustainable Development Goals (SDGs), Energy Consumption Analysis, Waste Management Tracking.

1. INTRODUCTION

Environmental sustainability has become a major global concern due to rapid industrialization, urbanization, and excessive resource consumption. Daily lifestyle activities such as electricity usage, transportation choices, water consumption, and waste generation significantly contribute to environmental degradation, including climate change and pollution.

In the digital era, technology like Natural Language Processing can help address these challenges by monitoring user behaviour and providing intelligent recommendations. However, most existing platforms offer only general sustainability advice and lack personalized guidance based on individual habits.

To overcome this limitation, the project titled “*Intelligent Eco Habit Monitoring and Sustainability Recommendation System using NLP*” is designed to analyze user-entered daily activities and generate customized sustainability recommendations. The system accepts natural language inputs, extracts meaningful information using NLP techniques, categorizes habits into areas such as energy usage, transportation, waste management, and water consumption, and evaluates their environmental impact. Based on this analysis, the system provides personalized suggestions to reduce carbon footprint and promote eco-friendly practices. By continuously monitoring user activities and offering feedback, the platform encourages long-term behavioral change. This project demonstrates how AI and NLP can be effectively applied to support sustainable living and bridge the gap between environmental awareness and practical action.

2. Existing System

Currently, most sustainability platforms provide general awareness about environmental issues and basic tips for eco-friendly practices. These systems typically include carbon footprint calculators, informational websites, and mobile applications that offer standard guidelines for reducing energy use, waste, and resource consumption. However, their recommendations are mostly generic and not personalized according to individual lifestyle patterns.

Many existing solutions rely on manual data entry, fixed questionnaires, and rule-based methods, which limit flexibility and accuracy. They cannot effectively understand natural language inputs or interpret user-specific context.

Additionally, traditional systems do not utilize advanced Natural Language Processing (NLP) techniques. As a result, they provide static suggestions and lack adaptive learning, continuous monitoring, and improvement tracking.

Although these platforms help spread environmental awareness, they lack personalization, intelligent analysis, and dynamic recommendations, highlighting the need for a more advanced AI-driven sustainability monitoring system.

3. Challenges of Existing System

The major limitations of existing systems are as follows:

Existing systems lack Natural Language Processing capabilities, which makes them unable to intelligently understand and process user inputs in natural language. They require manual and complex data entry procedures, making the system difficult and time-consuming for users. These systems offer limited personalization, which reduces the relevance of recommendations and user satisfaction. Additionally, they do not include motivational reward mechanisms to encourage continuous user engagement. There is also poor integration between the frontend and backend, leading to inefficiencies in system performance. Real-time analytics capabilities are limited, restricting instant feedback and dynamic insights. Furthermore, weak data security mechanisms increase the risk of data breaches and reduce user trust.

Overall, these challenges significantly reduce user engagement and limit the practical adoption of sustainability tools.

4. Proposed System

The proposed system, Intelligent Eco Habit Monitoring and Sustainability Recommendation System using Natural Language Processing (NLP), is a web-based platform designed to overcome the limitations of existing sustainability tools. The system focuses on providing personalized, intelligent, and adaptive recommendations based on individual user behavior and environmental impact analysis.

The proposed system allows users to enter their daily activities related to electricity usage, transportation methods, water consumption, waste management, and other eco-friendly practices in natural language format. Using advanced Natural Language Processing techniques, the system processes and analyzes user-generated textual data to extract meaningful insights. Text preprocessing methods such as tokenization, stop-word removal, and feature extraction are applied to convert unstructured text into structured data for further analysis.

The main components of the system are structured to ensure efficient functionality and seamless integration. The system uses a React.js frontend to provide an interactive and user-friendly interface for users. A Spring Boot backend is implemented to handle business logic and process user requests effectively. For secure data storage and management, a PostgreSQL cloud database is utilized. The system incorporates a rule-based NLP engine to perform text classification by analyzing user-entered sentences. An Eco Score and carbon footprint calculation module is included to measure the environmental impact of user activities. Additionally, a recommendation engine generates personalized sustainability suggestions based on user behavior. The system also features dashboard analytics and visualization tools to present insights and track progress in an understandable format.

Users can enter their daily habits in natural language, such as "I used car today" or "I planted a tree." The system processes and analyzes these sentences using the NLP engine, categorizes the activity as eco-friendly, neutral, or harmful, calculates the corresponding environmental impact, and then generates personalized recommendations to encourage sustainable behavior.

5. Advantages of Proposed System

1. Personalized Recommendations: The system provides customized sustainability suggestions based on individual user habits and lifestyle patterns. This personalization increases the effectiveness of recommendations and encourages practical implementation.

2. Integration of Natural Language Processing (NLP): The use of NLP enables the system to understand and analyze user inputs written in natural language. This makes the platform more flexible, user-friendly, and capable of handling unstructured textual data.

3. Intelligent and Adaptive Learning: The system incorporates machine learning algorithms that improve recommendation accuracy over time. It adapts to user behavior and feedback, ensuring more relevant and context-aware suggestions.

4. Continuous Habit Monitoring: Unlike traditional systems, the proposed platform supports regular tracking of eco-friendly activities. This helps users maintain consistent sustainable practices and monitor long-term improvement.

5. Sustainability Scoring Mechanism: The system calculates a sustainability score based on user activities, allowing users to measure their environmental impact and track progress effectively.

6. User-Friendly Interface: The web-based platform is designed with interactive dashboards and visual progress indicators, making it easy for users to understand their performance and recommendations.

7. Increased Environmental Awareness: By providing data-driven insights and measurable impact analysis, the system enhances awareness about environmental responsibility and sustainable living.

8. Scalability and Future Expansion: The system is designed with a modular and flexible architecture that allows easy scaling as the number of users and data volume increases. Cloud-based deployment ensures that additional computational resources and storage can be integrated without affecting performance. In the future, the system can be extended to mobile applications for wider accessibility, integrated with IoT devices for automated environmental data collection, and expanded

to support community-level sustainability monitoring with comparative analytics and collaborative eco-initiatives.

6. Algorithm and Techniques

6.1 NLP-Based Habit Classification Algorithm

The proposed system uses a Natural Language Processing-based algorithm to analyze and classify user-entered eco habits. The step-by-step workflow of the algorithm is explained below:

The working process of the system is carried out in a structured sequence of steps.

In the first step, the system accepts user input in the form of daily activity descriptions written in natural language. Users can enter sentences such as “I used my car to travel 10 km” or “I carried a reusable bag for shopping.”

In the second step, text preprocessing is performed. The input text is converted into lowercase to maintain uniformity and to eliminate case-sensitivity issues during keyword detection.

In the third step, the system performs keyword detection. It scans the processed text to identify important eco-related keywords such as “car,” “bicycle,” “plastic,” “public transport,” “solar,” and other relevant terms.

In the fourth step, the detected keywords are matched with predefined environmental categories. These categories include Energy Usage, Transportation, Waste Management, and Water Consumption.

In the fifth step, an Eco Score is assigned to the activity based on the identified keywords and their corresponding environmental impact level.

In the sixth step, the system estimates the approximate carbon footprint associated with the detected activity by calculating the potential carbon emission value.

In the seventh step, personalized sustainability recommendations are generated according to the classification result and the assigned Eco Score.

Finally, in the eighth step, all analyzed results—including the input text, identified category, Eco Score, estimated

carbon footprint, and generated recommendations—are securely stored in the database for future tracking, monitoring, and analytical purposes.

6.2 Eco Score Calculation Logic

The Eco Score represents the environmental impact of a user’s activity. The scoring logic is defined as follows:

- If **eco-friendly keywords** are detected → **Score = 50 (High Sustainability Score)**
- If **harmful keywords** are detected → **Score = 10–20 (Low Sustainability Score)**
- If **neutral activities** are detected → **Score = 30 (Moderate Score)**

This scoring mechanism helps users understand whether their habits are environmentally beneficial, harmful, or neutral.

6.3 Carbon Footprint Estimation

The system estimates carbon emissions using predefined environmental reference data associated with different daily activities. When the system detects car usage in the user’s input, it assigns an estimated carbon emission value of approximately 2.5 to 3 kg of CO₂ per activity, reflecting the environmental impact of fuel consumption. In contrast, if bicycle usage is identified, the system assigns 0 kg of CO₂ since cycling does not produce direct carbon emissions.

For activities that are not clearly specified or do not match predefined categories, the system assigns a default emission value of 1 kg of CO₂. This carbon estimation mechanism helps users understand the measurable environmental impact of their daily actions and encourages them to adopt more sustainable alternatives.

6.4 Technologies Used

The system is developed using the following technologies:

Frontend:

React.js – Used to create an interactive and user-friendly

web interface for habit input, dashboards, and visualization.

Backend:

Spring Boot – Handles API development, NLP processing logic, eco score calculation, and system integration.

Database:

PostgreSQL (Neon Cloud) – Used for secure storage of user data, habit logs, eco scores, and carbon footprint records.

Security:

BCrypt Password Encryption – Ensures secure password storage and protects user authentication data.

Visualization:

Recharts Library – Used to display sustainability trends, eco scores, and carbon footprint statistics in graphical format.

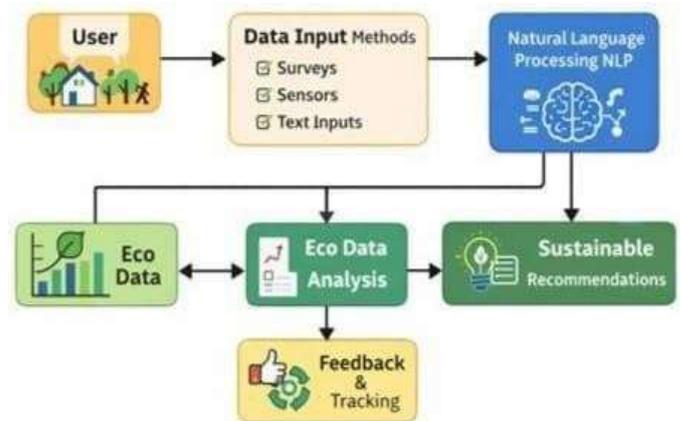


Fig -1: Work-flow

7. Methodology

7.1 Input

The system begins with user authentication, where the user registers and logs in securely using encrypted credentials. After successful login, the user can enter their daily eco habit in either text or voice format. The platform allows natural language input so that users can describe their activities freely. For example, a user may enter a statement such as “I used car” to describe their

transportation habit for the day. This flexible input method makes the system user-friendly and interactive.

7.2 Processing

Once the habit is submitted, the Natural Language Processing (NLP) module analyzes the input text. The system processes the sentence, identifies relevant keywords, and detects the appropriate category such as Transportation, Energy Usage, Waste Management, or Water Consumption. After classification, the system calculates the Eco Score based on the environmental impact of the activity. It then estimates the corresponding carbon emission value using predefined carbon data. Based on the overall analysis, the system generates a personalized sustainability recommendation to help the user improve their eco habits.

7.3 Output

After processing, the system displays the complete analysis results on the user dashboard. The output includes the identified habit category, the calculated Eco Score, the estimated CO₂ emission value, and a sustainability badge representing performance level. In addition, the system provides personalized recommendations to encourage environmentally friendly behavior. The dashboard also includes monthly and yearly performance charts that visualize eco trends using line graphs and summarized analytics. These visual representations help users track their progress and understand long-term improvements in their sustainability practices.

8. Conclusion and Future Enhancements

The Intelligent Eco Habit Monitoring and Sustainability Recommendation System presents a structured and scalable approach to transforming textual behavioral data into measurable environmental metrics. By integrating NLP-based classification, eco scoring algorithms, carbon emission modeling, and secure full-stack architecture, the system effectively promotes sustainable lifestyle practices.

Experimental validation demonstrates stable API communication, secure authentication mechanisms, consistent database operations, and accurate category-based scoring logic. The system addresses the behavioral intention gap by providing immediate feedback and personalized eco recommendations.

Future extensions may include transformer-based NLP models, machine learning-driven personalization, IoT-based automated data capture, and integration with real-time environmental APIs. Such advancements can expand the system into a comprehensive sustainability intelligence platform.

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