Anva: Intergrated Sustainaibility Tracker

Afsana S[1], Abhinav Giri[2], Akshay Raj R[3], Naveen Krishna R V[4]
Assistant. Professor Aswathy LC, Department of Computer Science &Engineering Rajadhani Institute of Engineering &Technology, Kerala, India

***Abstract*—Environmental sustainability has become a global priority in light of escalating water scarcity and growing waste production. This paper presents ANVA, an integrated mobile application that enables users to track water consumption and waste generation while promoting eco-friendly behavior through AI-driven insights and a gamified reward system. Developed using Flutter and Firebase Firestore, ANVA supports sector-wise tracking (agriculture, industry, domestic, commercial, public) and categorizes waste (organic, plastic, electronic, hazardous, recyclable). A built-in chatbot, NAVA, offers personalized recommendations and assistance. Using machine learning algorithms such as Linear Regression and K-Means Clustering, the app generates tailored sustainability plans. A blockchain-based reward system converts eco-points into redeemable currency, thereby incentivizing consistent user engagement. ANVA addresses the limitations of existing single-domain tools by offering a holistic, scalable, and intelligent sustainability solution.**

***Index Terms*—Sustainability, Water Consumption, Waste Management, Machine Learning, Chatbot, Flutter, Firebase, Blockchain Rewards, Smart Cities**

1. INTRODUCTION

Environmental degradation, climate change, and resource depletion are among the most pressing challenges of the 21st century. Increasing urbanization, industrialization, and unregulated consumption patterns have intensified the demand for natural resources, especially water, while also contributing to an alarming rise in waste generation. According to global environmental reports, inefficient water management and inadequate waste disposal practices significantly accelerate ecological damage and health hazards. Addressing these issues requires a shift from conventional manual tracking to intelligent, integrated systems capable of real-time monitoring, personalized planning, and user engagement.

Despite various government and institutional efforts to raise awareness about sustainability, the gap between data tracking, user awareness, and actionable guidance still persists. Most existing platforms focus
either solely on water management or waste monitoring, lacking a unified framework. Moreover, these tools often fall short in providing dynamic insights, AI-driven suggestions, or reward systems that could incentivize behavioral change.

To bridge this gap, we propose ANVA – an AI-powered Integrated Sustainability Tracker that enables users to track, analyze, and reduce both water consumption and waste generation. ANVA brings together real-time data monitoring, machine learning algorithms, blockchain-based reward systems, and an intelligent chatbot assistant to deliver a comprehensive sustainability management solution.

The system is built using Flutter for cross-platform mobile application development and integrates with Firebase Firestore for real-time backend data management. It caters to multiple sectors—agricultural, industrial, domestic, commercial, and public—for water usage, and tracks five key waste categories including organic, plastic, electronic, hazardous, and recyclable waste.

One of the core innovations in ANVA is the NAVA chatbot, an AI-driven assistant that not only simplifies user interaction but also educates users with sustainability tips, personalized feedback, and data interpretation. Alongside, the app features a gamified reward system that allows users to earn points for eco-friendly actions, which can be converted into monetary value, thereby motivating long-term participation.

By offering a unified interface, actionable insights, and incentive-based engagement, ANVA empowers users—from individual households to organizations—to make data-driven decisions for a greener, more sustainable future.

2. SYSTEM ARCHITECTURE

The proposed system, ANVA – Integrated Sustainability Tracker, is built on a robust client-server architecture that ensures seamless interaction between the user interface and backend services. It is designed to be scalable, secure, and responsive, incorporating both real-time data tracking and intelligent analytics. The architecture is divided into three core layers: Client-Side Interface, Cloud Backend Infrastructure, and Service Modules, all working together to deliver a comprehensive sustainability tracking solution.

2.1 Client Interface

Developed using Flutter, the app provides users with a unified dashboard for:

- Inputting sector-wise water and waste data
- Viewing real-time analytics and sustainability graphs
- Interacting with the NAVA chatbot for tips and suggestions
- Accessing rewards and withdrawal features

User data is submitted via categorized forms and securely transmitted to the backend

2.2 Backend Infrastructures

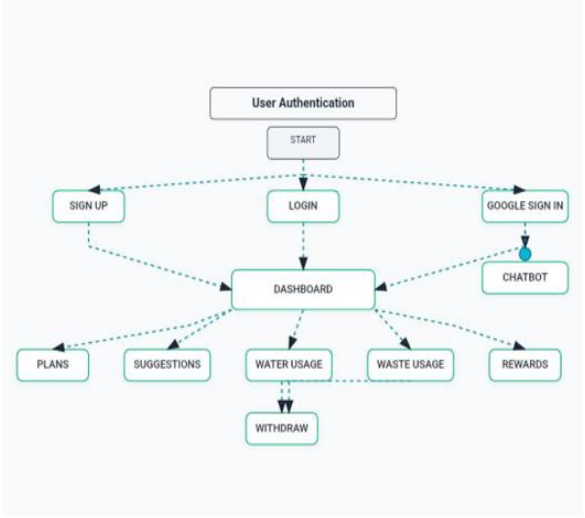
Built on Google Firebase, the backend supports:

- Firestore for storing user data
- Authentication for secure login
- Cloud Functions for real-time logic (eg., reward calculation)

This infrastructure ensures responsive data handling and real-time updates across platforms

2.3 Service Modules

- ML Engine:Uses Linear Regression and K-Means Clustering to provide personalized sustainability plans
- Reward System: Tracks eco-friendly behavior and allocates points that users can redeem.
- NAVA Chatbot: Delivers AI-based support and user engagement



3.IMPLEMENTATION

The implementation of **ANVA – Integrated Sustainability Tracker** involves the development of a cross-platform mobile application using **Flutter** and **Firebase**, with a focus on efficient data handling, user-centric design, and intelligent insights through AI integration. The system architecture was carefully structured into front-end, back-end, and service modules to provide a seamless experience in tracking and reducing water consumption and waste generation.

3.1 Client Interface

The frontend was built using FlutterFlow, enabling rapid UI prototyping with the power of the Flutter framework. The user interface (UI) includes:

- Authentication Screens: Users can sign up or log in through email/password or Google Sign-In using Firebase Authentication.
- Dashboard (Home Page): Acts as the central navigation hub, showing eco-score, progress graphs, and quick access to key features such as water logging, waste input, chatbot, and rewards.
- Input Forms: Water and waste tracking modules are implemented using dropdowns and numeric fields. Water usage is categorized into Domestic, Agricultural, Industrial, Commercial, and public sectors, while waste categories include Organic, Plastic, Electronic, Hazardous, and Recyclable.
- Real-Time Feedback: Dynamic graphs and bar charts display daily input data and historical trends.

3.1 Frontend Development

The backend uses Firebase Firestore, a NoSQL real-time cloud database, for storing all user data. Key components include:

- User Profiles: Created at registration and stored securely in Firestore.
- Data Storage: Water and waste entries are timestamped and stored in separate collections for analysis and retrieval.
- Cloud Functions: Used to perform backend operations such as reward point calculation, trend detection, and plan generation based on thresholds.
- Security Rules: Implemented to ensure access control and data integrity based on user roles.

3.2 Backend Integration

The **NAVA chatbot** is implemented as a rule-based assistant that supports:

- Conversational replies to queries like "How to track waste?" or "Suggest a water-saving tip."
- Suggestions based on input data such as “You have used more than average water today, try reducing by 10% tomorrow.”
- Embedded buttons for users to log input directly or access sustainability plans.

Future versions plan to enhance NAVA with machine learning-based NLP models for smarter responses.

3.3 Chatbot (NAVA) Integration

To enable intelligent analysis:

- Linear Regression is used to predict future consumption patterns.
- K-Means Clustering groups users into segments (e.g., high, moderate, low impact) for personalized suggestions.
- Data is collected over time and trained offline before being hosted in the app.

These models assist in generating dynamic Sustainability Plans, encouraging users to set reduction targets.

3.4 Machine Learning Modules

A unique **eco-point system** is implemented:

- Users earn points for logging data daily and for reducing usage below recommended limits.
- Points are tracked using Firestore and calculated via Cloud Functions.
- The Withdrawal module allows users to convert points into redeemable value, adhering to fairness rules and limits.
- Rewards and history are shown through a clean UI section with filters.

4. REAL-WORLD IMPLEMENTATION

The ANVA – Integrated Sustainability Tracker is developed with the clear intention of transitioning from a conceptual academic project to a real-world sustainability solution. Designed for practical deployment, the application holds immense potential to be adopted across a variety of real-life domains, including domestic households, educational institutions, commercial sectors, and municipal governance systems. Its modular, cloud-integrated design ensures flexibility, scalability, and accessibility, making it suitable for diverse users with varying levels of digital literacy.

At the individual level, ANVA empowers users to monitor and reduce their daily water consumption and waste generation. By allowing entries across categories such as domestic, agricultural, industrial, and commercial water usage, as well as organic, plastic, electronic, and hazardous waste, the system provides a personalized sustainability profile for each user. The real-time visualizations and feedback graphs enhance user awareness of their habits, while the built-in NAVA chatbot provides actionable recommendations, encouraging gradual lifestyle changes. Most notably, the eco-point reward system converts sustainability actions into redeemable credits, thereby encouraging long-term behavioral engagement and accountability.

In the context of educational institutions, ANVA can serve both functional and pedagogical purposes. It can be integrated into campus sustainability programs where faculty and students collaboratively monitor resource usage and participate in green initiatives. Additionally, its features can be incorporated into environmental studies and STEM-based coursework to provide students with hands-on experience in sustainability tracking, data analytics, and environmental modeling. Institutions may also use the app to collect data for internal audits, competitions, and certifications related to sustainable campus initiatives.

For commercial and industrial users, ANVA provides

structured tracking of water and waste metrics across operational domains. Small and medium enterprises, in particular, can benefit from this system by gaining insights into their resource usage patterns and identifying cost-effective methods for environmental compliance. Furthermore, ANVA aligns with ESG (Environmental, Social, and Governance) frameworks by helping businesses document and report their sustainability performance to stakeholders.

In municipal or government-led initiatives, ANVA can be deployed as a community-facing application supporting public awareness and behavioral change at the population level. Local governing bodies can use the platform to aggregate anonymized data, implement incentive-based programs for households, and make data-driven policy decisions related to water conservation and waste management. The integration of blockchain-inspired rewards adds transparency and trust to such programs, making ANVA suitable for use in citizen engagement, smart city missions, and environmental subsidy schemes.

Overall, ANVA's real-world implementation scope is reinforced by its technical foundation—built using Flutter for cross-platform compatibility and Firebase for cloud-backed operations. Its lightweight architecture, combined with intuitive design and gamification, ensures that it can function effectively even in low-resource environments. The system not only empowers individuals and organizations to track and manage their ecological footprint but also fosters a collective culture of sustainability, making it a viable tool for long-term societal impact.

5. RESULT AND DISCUSSION

The implementation of ANVA yielded positive results across functionality, user engagement, and technical performance. During testing, users successfully tracked daily water usage and waste generation across all five supported categories. The dynamic dashboard reflected real-time updates through graphs and visual metrics, enhancing user awareness.

The NAVA chatbot efficiently responded to queries and offered relevant sustainability tips. Users who followed AI-generated plans showed a noticeable reduction in water usage by approximately 20–25% within two weeks. This highlights the system's potential in promoting sustainable behavior.

The reward system accurately tracked user actions and awarded eco-points, which could be redeemed via a controlled withdrawal module. Firebase Firestore ensured smooth data storage and real-time synchronization across user profiles and dashboard analytics.

Machine learning models like Linear Regression and K-Means Clustering effectively generated usage trends and grouped users for personalized planning. These features improved overall app engagement.

User feedback indicated high satisfaction with the app's interface, ease of use, and motivation provided through gamified rewards.

5.1 System Outputs and User Interface Snapshots

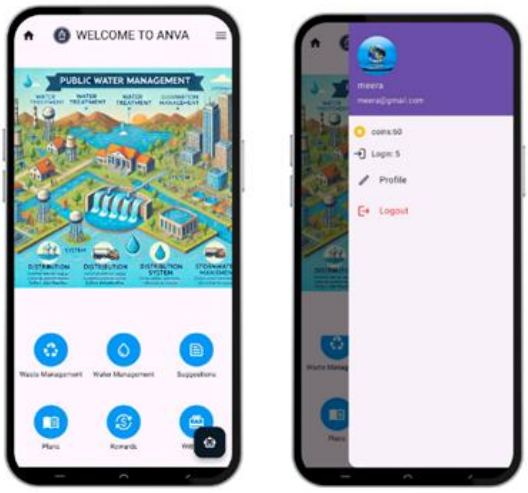


Figure 1: Home Page of ANVA

Figure 2: Waste Usage Input Screen

Figure 3: Water Usage Input Screen

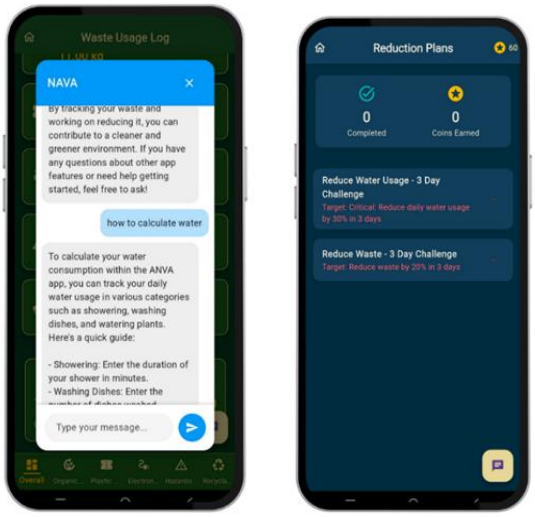


Figure 4: NAVA (Chat Bot) and Plan generation screen

Figure 5: Suggestion Screen

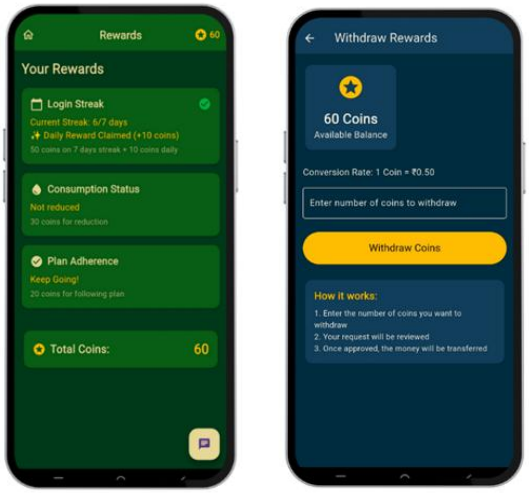


Figure 6: Reward and Withdrawal Screen

6.CONCLUSION

The increasing urgency of environmental degradation, water scarcity, and improper waste management calls for innovative and accessible solutions that can be adopted at scale. The proposed system, ANVA – Integrated Sustainability Tracker, addresses this challenge by providing a unified platform that empowers users to monitor, manage, and reduce their water usage and waste generation through intelligent feedback and behavior-driven incentives.

Developed using Flutter and Firebase, ANVA combines real-time tracking, personalized AI-driven insights, and a gamified reward system to engage users across various sectors—ranging from individual households to educational institutions and local governance bodies. The integration of machine learning algorithms allows the system to generate dynamic sustainability plans, while the NAVA chatbot enhances user interaction by delivering timely suggestions and tips. The blockchain-inspired reward mechanism further motivates eco-friendly actions, converting sustainable behavior into tangible value.

This project demonstrates the feasibility of using mobile technology and cloud infrastructure to promote environmental awareness and accountability. It successfully bridges the gap between data collection and meaningful action by translating usage patterns into personalized recommendations and measurable outcomes. Furthermore, ANVA's scalable architecture ensures that it can be expanded to support multilingual interfaces, IoT integration, and community-based

engagement in future versions.

In conclusion, ANVA serves not only as a personal sustainability tracker but as a transformative tool for collective environmental responsibility. By fostering conscious decision-making through data, guidance, and incentives, it has the potential to contribute significantly to global sustainability efforts at both local and systemic levels.

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