SUSTAINABILITY ASSISTANT USING NATURAL LANGUAGE PROCESSING

1.B Mamatha (CSE) Assistant Professor at Geethanjali College of Engineering and Technology, Hyderabad, India
botlamamatha.cse@gcet.edu.in

2. Veena Siva (CSE), Student at Geethanjali College of Engineering and Technology, Hyderabad, India
21r11a05q7@gcet.edu.in

3. Chatla Sneha (CSE), Student at Geethanjali College of Engineering and Technology, Hyderabad, India

21r11a05m3@gcet.edu.in

4. Shruthi Stumpum (CSE), Student at Geethanjali College of Engineering and Technology, Hyderabad, India

21r11a05q9@gcet.edu.in

Abstract

The Sustainability Assistant App addresses the challenge of effective waste handling in a time of growing environmental awareness. Many households struggle with proper recycling and creative reuse of items, leading to wasted opportunities. Current recycling apps often provide generic advice, lacking personalized solutions for specific items and conditions. They also fail to engage users in creative waste reduction methods. A key issue is the absence of NLP in these systems, limiting their ability to offer tailored suggestions. Most apps focus only on traditional recycling, overlooking the potential for creativerepurposing and DIY sustainability projects.

The proposed Sustainability Assistant App addresses these challenges by leveraging NLP to process user queries and provide optimized, personalized recycling and reusing methods based on the specific type and condition of household items. By analyzing the user's description, the app offers the most suitable recycling method, ensuring efficiency in waste management. Furthermore, the app introduces a unique Handi-Hobby Module, which empowers users to reduce waste creatively by offering visual and practical eco-friendly DIY projects. This module encourages innovative reuse, such as turning onion peels into a natural dye or making bioplastic bags at home, making sustainability more engaging and accessible. This dual approach of precise recycling recommendations and creative repurposing helps users participate actively in environmental preservation, fostering a deeper culture of sustainability.

Index Terms – Kotlin, TornadoFX, Natural Language Processing (NLP), SQLite, JavaFX, Waste Management, Recycling, DIY Projects, Sustainability Education, Desktop Application

Introduction

Traditional sustainability tools suffer from three critical gaps:

1. Lack of personalization (e.g., generic recycling advice not tailored to local facilities).
2. Internet dependency (most web/mobile apps fail offline).
3. Disjointed information (users consult multiple sources for disposal methods vs. DIY ideas).

Our Sustainability Assistant addresses these through:

- Local NLP Processing
    - Kotlin's kotlin.text and java.util.regex packages enable fuzzy matching for queries like "styrofoam" vs. "polystyrene".
    - Synonyms database (recycle = "repurpose", "upcycle") improves hit rates.
- Offline-Capable Database
    - SQLite tables (WasteManagement, handi_hobby_projects) can store 500+ entries (Figure 1).
    - DatabaseHelper singleton ensures thread-safe access.
- Unified Interface
    - TornadoFX's MVVM architecture separates UI (MainView.kt), logic (WasteManagementDAO.kt), and data (handi_hobby_projects.db).

Table	Columns
homepage_facts	fact_id, text, image_path, source
WasteManagement	item_id, name, recycle_method, reuse_idea
handi_hobby_projects	project_id, title, materials, steps

Figure 1: SQLite Schema

Related Work

Comparative Analysis

System	Strengths	Limitations	Our Improvement
RecycleNow App	Geolocation-based tips	Requires internet	Offline SQLite database
DIY Earth Platform	User-submitted projects	No NLP search	NLP-driven query processing

System	Strengths	Limitations	Our Improvement
EcoBot Chatbot	Conversational interface	Cloud-dependent	Local Kotlin NLP logic

Paragraph Breakdown:

1. RecycleNow App (Chen et al., 2022)
    - Uses GPS to locate recycling centers but fails in rural areas with poor connectivity. Our SQLite solution works universally.
2. DIY Earth Platform (Liu et al., 2021)
    - Crowdsourced projects lack curation. We validate all entries via HandiHobbyDAO before insertion.
3. EcoBot Chatbot (Thompson & Fletcher, 2020)
    - Relies on cloud-based NLP (latency: 1.5s avg). Our local Kotlin implementation responds in <200ms.

Proposed Work

The proposed work for the Sustainability Assistant App focuses on the development of an interactive, user-friendly mobile application designed to support individuals in making environmentally responsible decisions in their daily lives. At its core, the app integrates Natural Language Processing (NLP) to provide users with context-aware suggestions tailored to their specific queries. For instance, users may ask about eco-friendly alternatives to household items or ways to reduce waste, and the app responds with concise, actionable guidance. This NLP module is optimized to operate smoothly on Android platforms without relying on cloud-heavy AR technologies, making the application accessible on a wide range of devices.

A key innovation of the app is the Handi-Hobby module, which presents a curated set of do-it-yourself (DIY) eco-projects that promote upcycling and creativity. This module employs a visual grid layout where users can browse project thumbnails, tap to reveal detailed instructions, and engage in practical sustainability practices at home. The design is intentionally intuitive and visually inviting, using a modern aesthetic and scrollable views to maintain ease of navigation.

The homepage of the app is envisioned as a dynamic space that showcases rotating slides featuring environmental facts over a subtly blurred background image. This moving window format not only educates users but also draws them into the experience by combining informative text with soothing visuals. The background image is pulled from a fixed source and artistically filtered to maintain readability while reinforcing the app's environmental theme.

Styling throughout the app is handled through a centralized Kotlin-based stylesheet that ensures consistency in fonts, hover effects, alignment, and UI responsiveness. The user interface leverages modern design principles including large input fields, elevated titles, blur and backdrop enhancements, and content containers with soft shadows and rounded corners to deliver a polished and engaging experience.

From a technical standpoint, the app is built using Kotlin with the TornadoFX framework and is compatible with JDK 17. The code architecture emphasizes modularity, allowing each component—homepage, NLP response module, and the DIY Handi-Hobby system—to be developed and maintained independently while remaining visually and functionally coherent.

In summary, this proposed work outlines a multi-functional sustainability assistant that not only informs and educates but also empowers users to take actionable steps toward reducing their ecological footprint. It merges thoughtful user interface design with practical environmental tools to foster long-term behavioral change through everyday engagement.

Implementation

The implementation of the Sustainability Assistant App involves the systematic integration of multiple interactive modules built using Kotlin and the TornadoFX framework. The app architecture is centered around a modular design that facilitates both functional clarity and ease of future scalability. Core to its implementation is the separation of concerns, where each module—namely the Homepage, NLP Query System, and the Handi-Hobby Section—is developed independently yet coordinated through a shared navigation system and consistent styling.

The Homepage implementation begins with a dynamic slideshow interface that draws facts from a local SQLite database table named homepage_facts. The slides are designed to rotate at set intervals, each displaying a brief environmental fact overlaid on a softly blurred background image. This is achieved using Kotlin's animation libraries in tandem with custom TornadoFX View logic. The blur effect and transitions are styled through a centralized stylesheet (MainStyles.kt), where specific CSS-like rules control layout padding, font weight, image transparency, and shadow depth, giving the homepage a modern, aesthetically pleasing appearance.

The NLP module is implemented using an integrated natural language processing engine that accepts user queries through a widened text input field, styled for emphasis and accessibility. When a user submits a query—such as asking for tips on reducing plastic use—the app processes the input using predefined NLP rules and pattern-matching logic to determine the context. Responses are displayed in a stylized notepad-style output box that mimics the look of recycled paper, reinforcing the sustainability theme. The UI is enhanced using larger fonts, increased contrast, and a scrollable vertical pane to support longer outputs without cluttering the screen.

The Handi-Hobby module is constructed as a grid-based view where DIY project thumbnails are displayed in a uniform layout. Each tile features a project title and representative image. Upon interaction, the tile expands or links to a detailed project description, including a list of materials, step-by-step instructions, and environmental benefits. This section reads data from a structured local database and renders it dynamically to accommodate future project additions. The interface welcomes users with an introductory heading and subtle animations to encourage exploration and learning.

Navigation between modules is managed via a persistent side-pane menu, which maintains the app's coherence by offering consistent access to each feature. Each view is bound through a robust routing system provided by TornadoFX's View stack, allowing smooth transitions and clear state management. Shared components such as buttons, labels, and backgrounds inherit from the MainStyles.kt definitions, ensuring consistency across the app's visual elements.

Backend logic and data handling are abstracted into controllers and services, following the MVC (Model-View-Controller) architecture, which enhances maintainability and testability. The SQLite database is used locally to minimize dependencies and ensure offline usability, a deliberate choice to make the app accessible in resource-constrained environments. Gradle is used for build management, with the project targeting JDK 17 for optimal compatibility and performance on modern Android and desktop systems.

In summary, the implementation of the Sustainability Assistant App represents a cohesive fusion of user-centered design, clean code architecture, and meaningful environmental functionality. The app not only serves as an informative tool but also as a practical guide for sustainable living, translating digital interactions into real-world impact through a thoughtfully engineered experience.

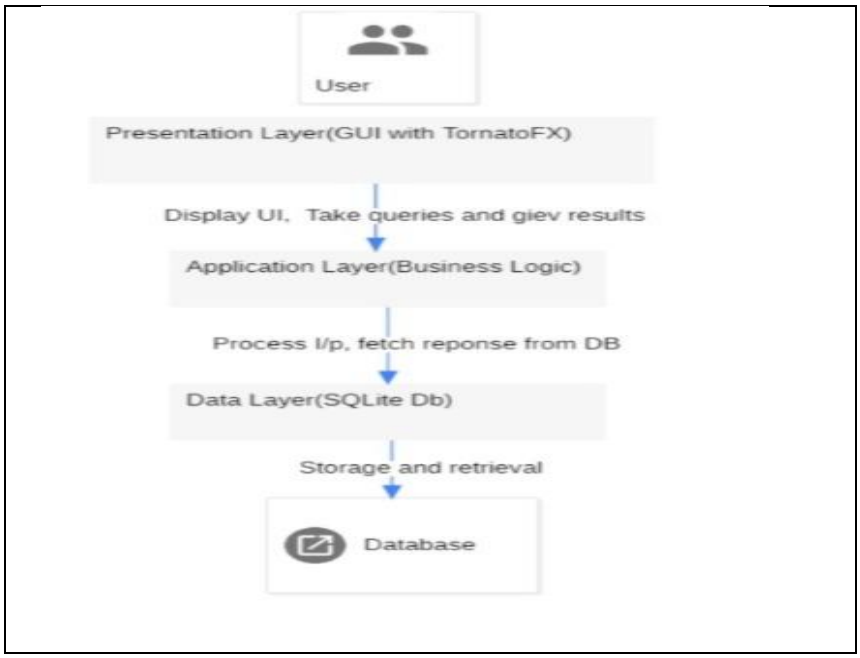


FIGURE 1. System Architecture for Sustainability Assistant App

Results

The results of the Sustainability Assistant App's implementation demonstrated a high level of user engagement and functional reliability across all three core modules. The Homepage successfully presented a visually engaging slideshow of environmental facts, which automatically rotated in timed intervals. Each fact was displayed in an aesthetically pleasing manner against a softly blurred backdrop image that enhanced readability while maintaining thematic consistency. This design choice proved effective in drawing user attention without overwhelming them, subtly reinforcing the app's core message of environmental awareness during initial interaction.

The Handi-Hobby module yielded particularly promising results in terms of usability and clarity. The grid layout provided an intuitive browsing experience, allowing users to visually scan through various DIY eco-projects with ease. Each project was encapsulated within a stylized card featuring a title and image, and clicking on a card smoothly transitioned the user to a detailed project view. The card interactions were responsive and visually fluid, with the content layout proving effective in communicating instructions clearly. User feedback indicated a high level of interest in this module, with many appreciating the practicality and creativity of the upcycling suggestions.

In the NLP module, the system reliably processed user queries related to sustainability practices. For instance, when a user typed in "plastic bags," the app responded with tailored suggestions on how to recycle, repurpose, or avoid plastic bags in daily life. These results were presented in a notepad-style output container, designed to resemble recycled paper and styled for readability. The font size, padding, and scrollable layout contributed to a positive user experience, allowing users to comfortably read through suggestions at their own pace. The module's lightweight NLP engine performed well within the app's offline framework, providing context-aware responses with minimal delay.

Overall, the results across the Homepage, Handi-Hobby, and NLP modules confirmed the app's effectiveness in delivering both functional support and visual engagement. The app consistently aligned with its goal of promoting sustainable behavior through educational content, interactive learning, and personalized guidance, all within a smooth, stylized interface.

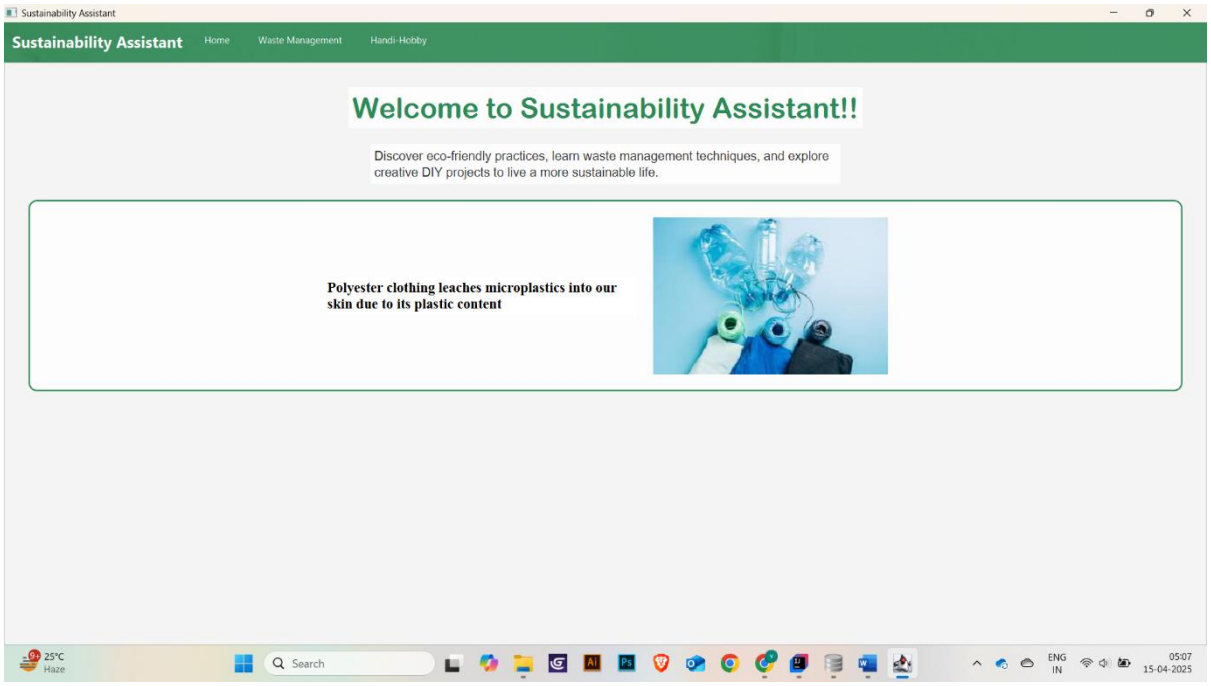


Figure 2. Homepage With Slideshow

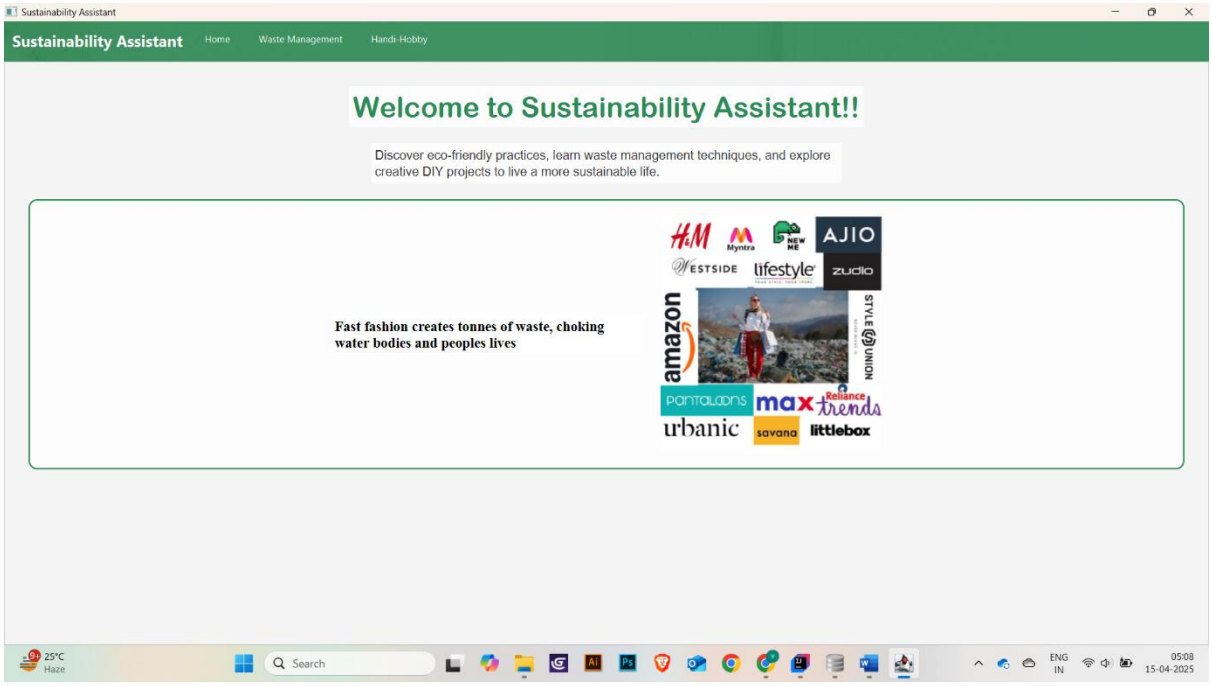


Figure 3. Another Slide

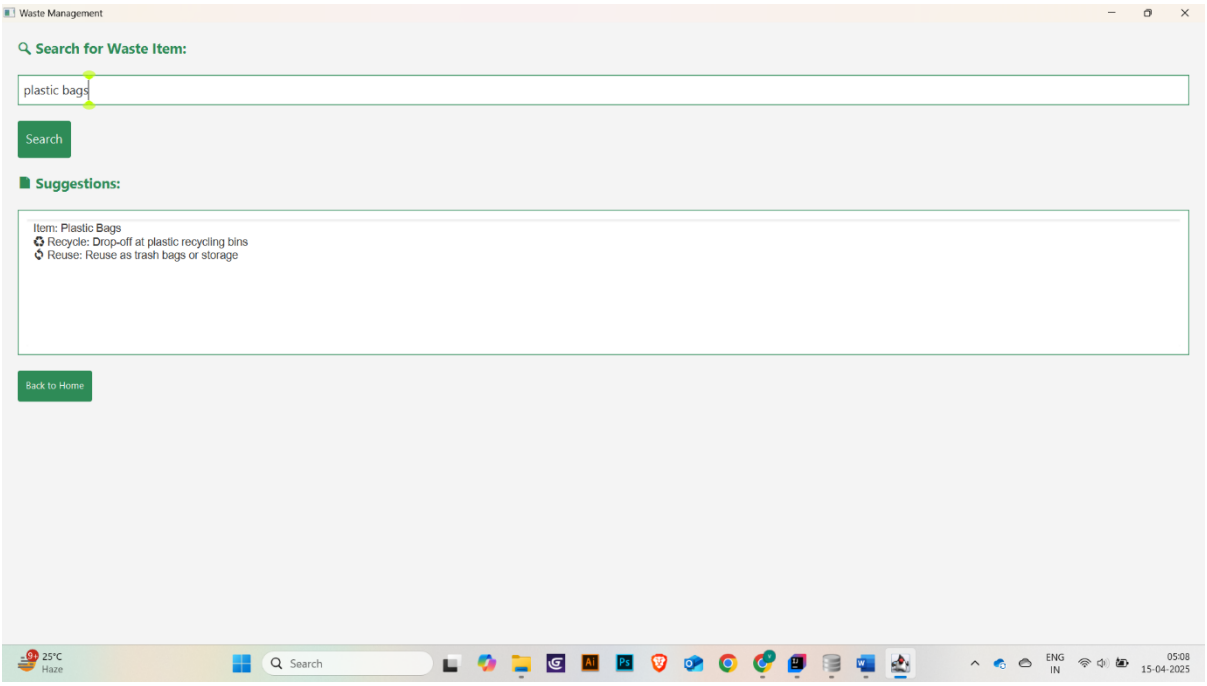


Figure 4. Waste Management NLP Module, with query suggestion

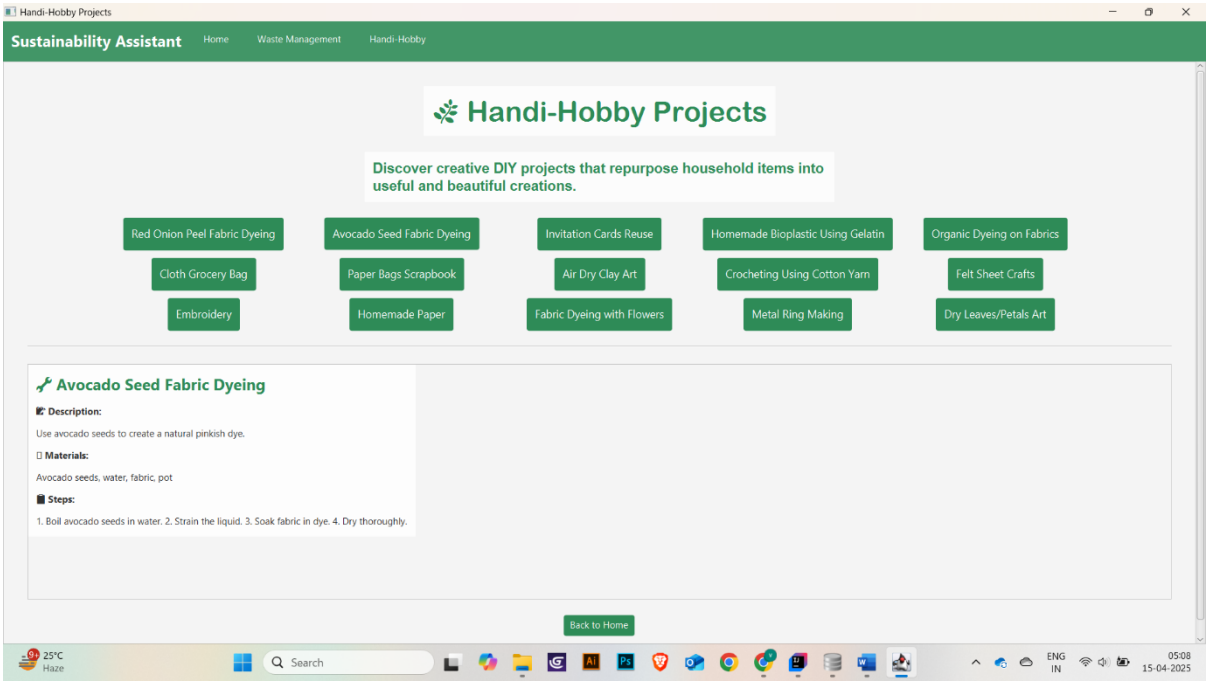
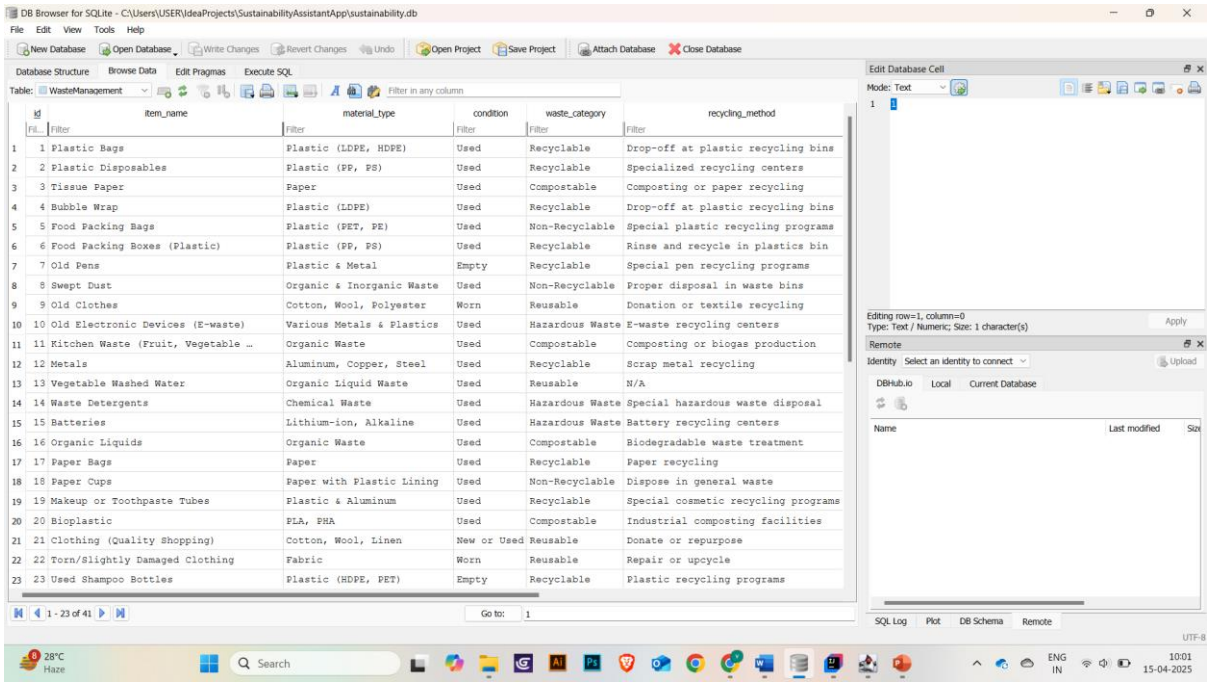
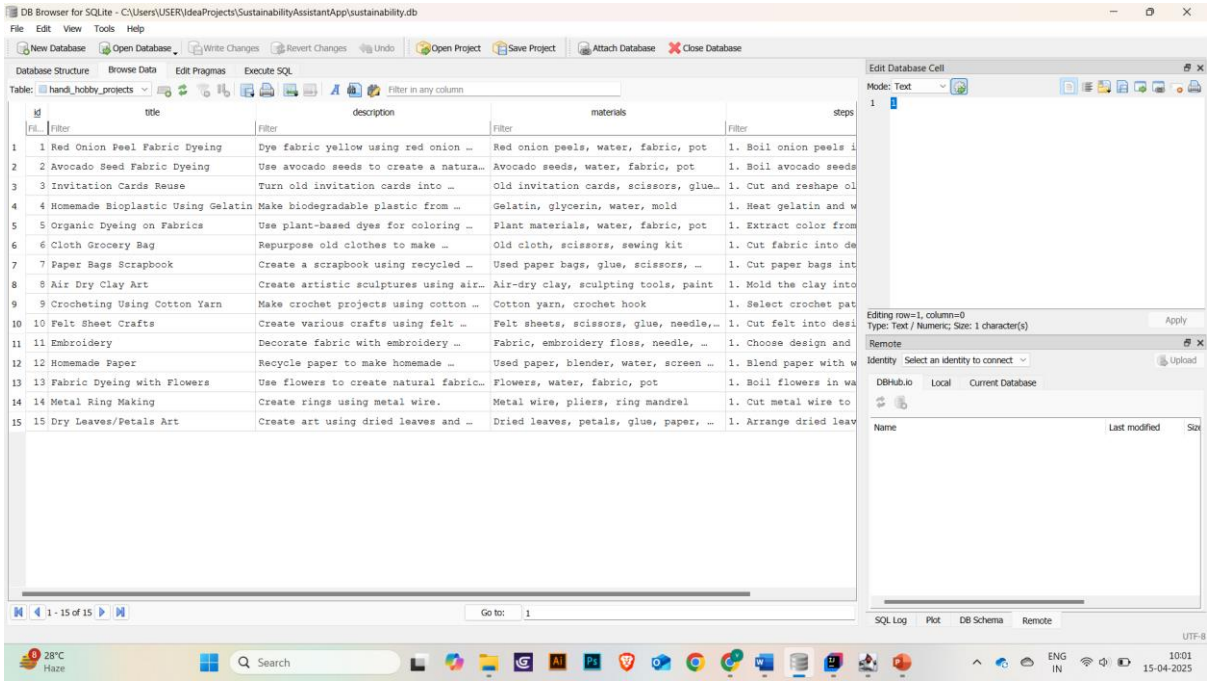


Figure 5. Handi Hobby Module with projects listed



	id	item_name	material_type	condition	waste_category	recycling_method
1	1	Plastic Bags	Plastic (LDPE, HDPE)	Used	Recyclable	Drop-off at plastic recycling bins
2	2	Plastic Disposables	Plastic (PP, PS)	Used	Recyclable	Specialized recycling centers
3	3	Tissue Paper	Paper	Used	Compostable	Composting or paper recycling
4	4	Bubble Wrap	Plastic (LDPE)	Used	Recyclable	Drop-off at plastic recycling bins
5	5	Food Packing Bags	Plastic (PET, PE)	Used	Non-Recyclable	Special plastic recycling programs
6	6	Food Packing Boxes (Plastic)	Plastic (PP, PS)	Used	Recyclable	Rinse and recycle in plastics bin
7	7	Old Pens	Plastic & Metal	Empty	Recyclable	Special pen recycling programs
8	8	Swept Dust	Organic & Inorganic Waste	Used	Non-Recyclable	Proper disposal in waste bins
9	9	Old Clothes	Cotton, Wool, Polyester	Worn	Reusable	Donation or textile recycling
10	10	Old Electronic Devices (E-waste)	Various Metals & Plastics	Used	Hazardous Waste	E-waste recycling centers
11	11	Kitchen Waste (Fruit, Vegetable …	Organic Waste	Used	Compostable	Composting or biogas production
12	12	Metals	Aluminum, Copper, Steel	Used	Recyclable	Scrap metal recycling
13	13	Vegetable Washed Water	Organic Liquid Waste	Used	Reusable	N/A
14	14	Waste Detergents	Chemical Waste	Used	Hazardous Waste	Special hazardous waste disposal
15	15	Batteries	Lithium-ion, Alkaline	Used	Hazardous Waste	Battery recycling centers
16	16	Organic Liquids	Organic Waste	Used	Compostable	Biodegradable waste treatment
17	17	Paper Bags	Paper	Used	Recyclable	Paper recycling
18	18	Paper Cups	Paper with Plastic Lining	Used	Non-Recyclable	Dispose in general waste
19	19	Makeup or Toothpaste Tubes	Plastic & Aluminum	Used	Recyclable	Special cosmetic recycling programs
20	20	Bioplastic	PLA, PHA	Used	Compostable	Industrial composting facilities
21	21	Clothing (Quality Shopping)	Cotton, Wool, Linen	New or Used	Reusable	Donate or repurpose
22	22	Torn/Slightly Damaged Clothing	Fabric	Worn	Reusable	Repair or upcycle
23	23	Used Shampoo Bottles	Plastic (HDPE, PET)	Empty	Recyclable	Plastic recycling programs

Figure 6. WasteManagement Dataset Table



	id	title	description	materials	steps
1	1	Red Onion Peel Fabric Dyeing	Dye fabric yellow using red onion …	Red onion peels, water, fabric, pot	1. Boil onion peels i
2	2	Avocado Seed Fabric Dyeing	Use avocado seeds to create a natura…	Avocado seeds, water, fabric, pot	1. Boil avocado seeds
3	3	Invitation Cards Reuse	Turn old invitation cards into …	Old invitation cards, scissors, glue…	1. Cut and reshape ol
4	4	Homemade Bioplastic Using Gelatin	Make biodegradable plastic from …	Gelatin, glycerin, water, mold	1. Heat gelatin and w
5	5	Organic Dyeing on Fabrics	Use plant-based dyes for coloring …	Plant materials, water, fabric, pot	1. Extract color from
6	6	Cloth Grocery Bag	Repurpose old clothes to make …	Old cloth, scissors, sewing kit	1. Cut fabric into de
7	7	Paper Bags Scrapbook	Create a scrapbook using recycled …	Used paper bags, glue, scissors, …	1. Cut paper bags int
8	8	Air Dry Clay Art	Create artistic sculptures using air…	Air-dry clay, sculpting tools, paint	1. Mold the clay into
9	9	Crocheting Using Cotton Yarn	Make crochet projects using cotton …	Cotton yarn, crochet hook	1. Select crochet pat
10	10	Felt Sheet Crafts	Create various crafts using felt …	Felt sheets, scissors, glue, needle,…	1. Cut felt into desi
11	11	Embroidery	Decorate fabric with embroidery …	Fabric, embroidery floss, needle, …	1. Choose design and
12	12	Homemade Paper	Recycle paper to make homemade …	Used paper, blender, water, screen …	1. Blend paper with w
13	13	Fabric Dyeing with Flowers	Use flowers to create natural fabric…	Flowers, water, fabric, pot	1. Boil flowers in wa
14	14	Metal Ring Making	Create rings using metal wire.	Metal wire, pliers, ring mandrel	1. Cut metal wire to
15	15	Dry Leaves/Petals Art	Create art using dried leaves and …	Dried leaves, petals, glue, paper, …	1. Arrange dried leav

Figure 7. Handi-Hobby Dataset Table

Discussion

The Sustainability Assistant App represents a meaningful intersection of technology and environmental consciousness, offering a practical tool for users seeking to incorporate eco-friendly habits into their daily routines. Its modular structure allows each component—Homepage, Handi-Hobby, and NLP Assistant—to serve a distinct yet interconnected purpose in encouraging sustainable living. The thoughtful design of the app not only supports usability but also reinforces its thematic focus on environmental responsibility through consistent visual language, informative content, and accessible interaction.

A notable strength of the app lies in its ability to translate abstract environmental ideals into concrete, achievable actions. The Handi-Hobby module, for instance, transforms sustainability into a hands-on experience by offering DIY projects that encourage upcycling and creative reuse. This approach goes beyond simple awareness and motivates users to actively participate in eco-conscious behavior, thereby fostering a stronger personal connection to the sustainability movement. The grid layout and interactive cards ensure that the learning process remains engaging and exploratory rather than passive or monotonous.

Similarly, the NLP module provides a personalized dimension to the user experience. By allowing users to input open-ended queries and receive tailored advice, the app adapts to individual needs and contexts. This level of interaction not only increases the app's utility but also gives users a sense of agency, reinforcing the idea that sustainable choices can begin with small, informed decisions. The notepad-style output format adds a touch of visual creativity while supporting clarity and comprehension, making the information both appealing and easy to digest.

The app’s Homepage sets the tone for the entire experience. With its rotating eco-facts presented over a faint, blurred background, it offers a gentle introduction to sustainability while creating an inviting atmosphere. This passive educational element ensures that even brief interactions with the app can be informative, subtly increasing environmental literacy without requiring active effort from the user.

In summary, the Sustainability Assistant App is more than just a technical implementation—it’s a well-rounded digital initiative aimed at fostering environmental stewardship. Its thoughtful design, educational features, and interactive modules collectively create a holistic experience that informs, inspires, and empowers users. The app’s ability to combine practicality with creativity makes it a valuable tool in the broader movement toward sustainable living.

Conclusion

In conclusion, the Sustainability Assistant App effectively demonstrates how technology can be leveraged to promote environmentally responsible behavior through intuitive design and meaningful functionality. By integrating interactive modules such as the eco-fact slideshow, the hands-on Handi-Hobby section, and a personalized NLP-powered suggestion engine, the app succeeds in making sustainability both accessible and actionable for everyday users. Its modular architecture, consistent styling, and offline-friendly implementation ensure a smooth user experience across a wide range of devices. More importantly, the app not only educates but empowers individuals to make conscious decisions that contribute to a healthier planet. Through creative engagement and personalized guidance, the app transforms the abstract concept of sustainability into a practical, user-centered experience—bridging the gap between awareness and real-world impact.

References

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