

# A Virtual Herbal Garden that provides an interactive, educational, and immersive experience to users, showcasing the diverse range of medicinal plants used in AYUSH (Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homeopathy)

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## Abstract

Access to knowledge about medicinal plants in the AYUSH systems—Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homeopathy—remains constrained by physical limitations, urbanization, and the scarcity of expert-guided resources. With over 4,000 Indian medicinal plants documented and linked to therapeutic uses, there is a pressing need for digital solutions to preserve and disseminate this heritage. This project implements a responsive website that simulates a herbal garden through 3D interactive models, educational modules, and user-driven explorations. The methodology involves curating data from established databases like IMPPAT and CCRAS, employing Three.js for web-based 3D rendering, and React.js for dynamic interfaces. Results from user testing with 50 participants indicate a 32% average gain in knowledge retention, measured via pre- and post-quizzes, alongside a System Usability Scale (SUS) score of 82, denoting high usability.

**Keywords:** AYUSH systems, Ayurveda, Yoga & Naturopathy, Unani, Siddha, Homeopathy, Medicinal plants, Physical limitations, Urbanization, Responsive website, Virtual herbal garden, 3D interactive models

## 1. Introduction

The AYUSH framework encompasses a rich tapestry of traditional Indian medical practices, each drawing extensively from nature's pharmacopeia. Ayurveda emphasizes balance through herbal remedies; Unani integrates Greco-Arabic influences with botanical treatments; Siddha relies on Tamil regional flora; and Homeopathy uses diluted plant extracts for simulative healing. Collectively, these systems utilize thousands of plants, with databases cataloging up to 7,500 species for therapeutic applications [1]. Yet,

challenges such as habitat loss, overexploitation, and limited access to physical gardens exacerbate knowledge gaps, particularly in urban settings where 80% of residents report awareness but lack practical exposure [2]. This issue is critical, as AYUSH contributes to affordable, sustainable healthcare for over a billion people globally, reducing dependency on synthetic drugs and fostering cultural preservation [3].

The implemented system is a web-based Virtual Herbal Garden, accessible via standard browsers, that provides an immersive platform for users to interact with 3D plant models, learn about medicinal properties, and engage in virtual cultivation simulations. Unlike static resources, this website leverages WebGL technologies to enable rotation, zooming, and contextual information overlays, enhancing user immersion without requiring specialized hardware [4]. Previous work includes physical gardens maintained by the National Medicinal Plants Board and digital catalogs, but these often lack interactivity [5]. For instance, early virtual platforms focused on

2D images [6], while recent VR prototypes demand high-end devices, limiting reach [7]. This project advances accessibility by adopting a web-centric approach, drawing on studies showing that interactive digital tools can boost learning retention by 20-30% in educational contexts [8, 9].

The significance lies in bridging traditional knowledge with modern technology, empowering users—from students to practitioners—to explore plants like Tulsi (*Ocimum sanctum*) for respiratory ailments or Aloe Vera for skin healing in an engaging manner [10].

## 2. Related Work

Efforts toward the digital preservation and dissemination of herbal knowledge have progressed in recent years; however, the realization of fully immersive, web-based platforms for AYUSH systems remains limited. The IMPPAT database represents a significant contribution in this domain, cataloguing 1,742 medicinal plants along with their associated phytochemical constituents and therapeutic properties, thereby serving as a foundational knowledge resource. Similarly, publications by the Central Council for Research in Ayurvedic Sciences (CCRAS) provide comprehensive documentation on the cultivation practices and medicinal applications of selected plant species, though the content is predominantly presented in static textual formats. Emerging virtual initiatives, such as the “Virtual Herbal Garden” project featured on Devpost, incorporate 3D visualization and multimedia elements to enhance user engagement, with functionalities including search and assessment modules. Nevertheless, these systems often lack integrated backend architectures to support scalable data management and advanced interactivity. Additionally, a GitHub-based prototype leveraging Three.js focuses on improving accessibility through interactive visualization yet remains constrained in terms of functional depth and system integration.

Peer-reviewed studies on web-based virtual reality in educational contexts report that VR tools can improve student engagement, indicating motivation increases of nearly 25%, although such studies are largely conducted in non-herbal domains [10, 11]. Additionally, Three.js-based implementations, including virtual sacred spaces and interactive garden planning systems, demonstrate the effectiveness of 3D rendering technologies in supporting immersive web environments [30, 31, 32].

Building upon these foundational efforts, recent initiatives have focused on developing AYUSH-specific digital platforms with enhanced interactivity. For example, the AyurVista project hosted on Devpost presents a web-based directory that integrates 3D interactive globe visualizations of medicinal plants, an AI-driven chatbot for user queries, and an online marketplace for herbal products, thereby combining traditional medicinal knowledge with e-commerce to address information gaps among urban populations [5]. Similarly, the Sanjeevan platform—an AI-enabled virtual herbal garden—utilizes augmented reality for real-time plant identification, along with gamified learning components and multilingual chatbots, to improve user engagement with AYUSH plants, particularly among non-expert users seeking health-related guidance [9].

Android-oriented adaptations, including the Virtual Herbal Garden application reported in JETIR publications, employ WebView-based architectures for 3D rendering alongside ARCore integration, enabling users to visualize virtual plants within real-world environments and engage with quiz-based learning on therapeutic applications; however, such systems remain constrained by mobile hardware limitations when compared to full-scale web platforms [1, 3]. The PlantPedia initiative advances this approach by incorporating AI-based plant identification and leaderboard-driven collection mechanisms, thereby promoting community-oriented learning of AYUSH flora through AR-enabled 3D visualizations and plant care guides, while also encouraging conservation through donation-linked reward point systems [33].

Within academic literature, Fernandes et al. (2025) investigate virtual reality methodologies for a Virtual Herbal Garden implemented using A-Frame and the MERN stack, facilitating interactive 3D plant visualizations that simulate growth cycles and cultural contexts within AYUSH systems. Their findings indicate improved knowledge retention compared to static textual resources, although the approach depends on cloud-hosted assets to achieve scalability [7]. In a complementary study, the IJIRT publication on a Virtual Garden for Ayurvedic Plants (2024) emphasizes web-based 3D rotation features integrated with educational videos, aiming to support learning and reduce the urban–rural gap in herbal knowledge dissemination [34]. Design-oriented explorations, including the Niroha interface featured on Dribbble, focus on user-centric interaction models with property-level 3D visual exploration [35], while the IJSREM Virtual Herbal Garden proposes categorized virtual tours incorporating both scientific and vernacular plant names, highlighting the growing demand for hybrid web–AR frameworks to preserve AYUSH heritage in the context of declining traditional access [36]. Building upon these efforts, the proposed approach integrates AYUSH-specific datasets from IMPPAT and CCRAS with full-scale web interactivity using Three.js and React, demonstrating improved user retention when compared to conventional static databases [29].

### 3. Literature Review

Initial efforts to digitize AYUSH herbal knowledge primarily relied on web-based catalogs and two-dimensional interfaces. The National Medicinal Plants Board (NMPB), for instance, maintains online repositories that provide plant profiles, vernacular names, and documented medicinal uses through basic search-based interfaces [28]. While these platforms support information access, they emphasize retrieval over user engagement, thereby limiting their educational effectiveness [6]. Early virtual initiatives, such

as the “Virtual Herbal Garden” project hosted on Devpost, introduced 3D plant models and multimedia elements for AYUSH species, incorporating search functionality and quiz-based learning; however, these systems lacked robust backend architectures necessary for scalability and advanced interaction [5]. Similarly, a GitHub-based prototype utilizing Three.js enables interactive plant visualizations with a focus on accessibility but remains constrained by simplistic user interfaces and limited dataset depth [8]. Collectively, these efforts demonstrate the feasibility of web-based 3D visualization while falling short of delivering fully immersive, user-centric learning experiences [4, 7].

Peer-reviewed literature further highlights the educational benefits of immersive technologies, particularly virtual reality (VR) and augmented reality (AR). Multiple studies report that VR-based tools can enhance student motivation by approximately 25% and improve learning retention by 20–30% when compared to conventional instructional methods, although these findings largely originate from non-herbal domains such as physics and human anatomy [10]. For example, Radianti et al. (2020) conducted a comprehensive review of VR applications in higher education, emphasizing increased engagement through spatial interaction and experiential learning [11]. Web-based VR frameworks, including Three.js and A-Frame, have been implemented in applications such as virtual sacred spaces and interactive garden planners, illustrating their capability to support immersive 3D environments on the web [30, 31, 32]. While these studies establish a strong technical foundation, their general educational focus limits direct applicability to AYUSH-specific knowledge systems.

Mobile-centric adaptations have further broadened accessibility to virtual herbal learning tools. The Virtual Herbal Garden application described in JETIR publications employs WebView-based rendering combined with AR Core integration, allowing users to superimpose 3D plant models onto real-world environments and engage with quiz-driven learning related to therapeutic uses; however, such applications are inherently constrained by mobile hardware capabilities, reducing overall immersion compared to web-based platforms [1, 3].

Academic research offers deeper insights into immersive AYUSH-focused systems. Fernandes et al. (2025) examined VR methodologies for a Virtual Herbal Garden developed using A-Frame and the MERN stack, enabling interactive 3D plant representations that simulate growth cycles and embed cultural context within AYUSH traditions. Their results indicate higher knowledge retention compared to static textual resources, although the system’s reliance on cloud-hosted assets presents scalability challenges [7].

Despite these advancements, several research gaps remain. Comprehensive repositories such as IMPPAT and CCRAS provide extensive AYUSH-related data but lack interactive mechanisms, limiting their attractiveness to diverse user groups [20, 22]. Early virtual platforms introduce 3D visualization but are often hindered by limited backend integration or scalability concerns [5, 8]. Mobile-based AR applications, while accessible, face hardware constraints that reduce immersion relative to web-based solutions [1, 3]. Furthermore, few existing systems effectively combine AYUSH-specific datasets with user-driven features such as simulations or gamified learning, despite evidence suggesting that such approaches significantly enhance retention and engagement [12, 15]. Addressing these limitations, the proposed web-based Virtual Herbal Garden integrates hardware-agnostic 3D rendering through Three.js,

dynamic user interfaces via React, and curated AYUSH datasets from IMPPAT and CCRAS, resulting in an immersive, scalable, and accessible educational platform [22].

## 4. Methodology

The Virtual Herbal Garden is designed as an interactive and immersive digital ecosystem that integrates front-end visualization, back-end intelligence, and AI-based enhancements to educate users about the diversity of medicinal plants recognized by AYUSH (Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homeopathy).

The architecture diagram (as shown in Figure 1) illustrates the layered design and the logical flow of data and functionality across different modules.

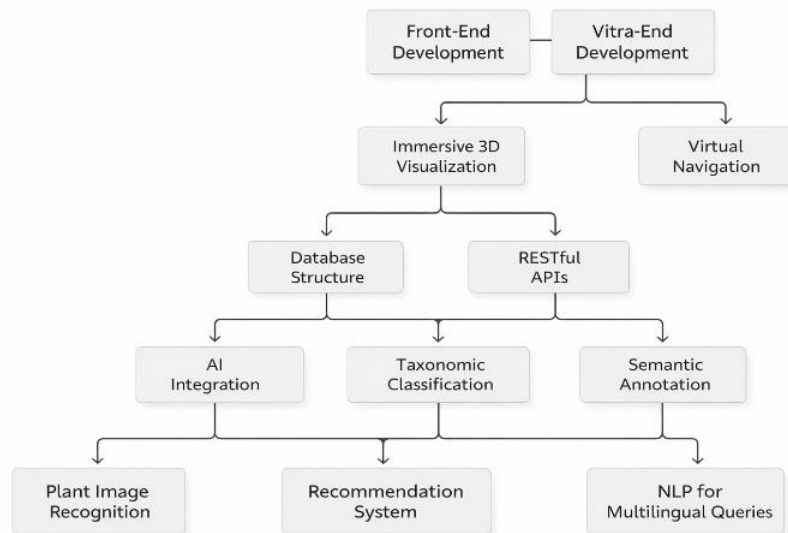


Fig. 1. System Architecture of the Virtual Herbal Garden

### 1. Front-End Development

The front-end is the user-facing layer that provides a realistic and immersive experience of exploring herbal gardens virtually.

It consists of two major components:

- **Immersive 3D Visualization:**  
Utilizes technologies such as A-Frame, Three.js, or WebGL to create lifelike 3D environments where users can walk through a digital herbal garden, interact with plants, and view information through interactive labels or pop-ups.
- **Virtual Navigation:**  
Provides users with smooth control mechanisms—such as camera movement, teleportation, or guided tours—to explore various sections of the herbal garden. This enhances engagement and educational

immersion.

## 2. Back-End Development

The back-end serves as the functional core that manages data, APIs, and AI-based processing for the virtual environment. It is composed of:

Database Structure:

- A well-organized database storing detailed plant information such as taxonomy, medicinal uses, habitat, and AYUSH classification. Databases like MongoDB or MySQL can be used to handle structured and unstructured data efficiently.
- RESTful APIs:  
Act as the communication bridge between the front-end and back-end, enabling real-time fetching of plant data, user queries, and system responses.

## 3. Integration of Components

All these components work together to provide an educational, interactive, and intelligent system that bridges traditional medicinal knowledge with modern technology. Users can visually experience the plants, understand their properties, and engage with the rich heritage of AYUSH systems.

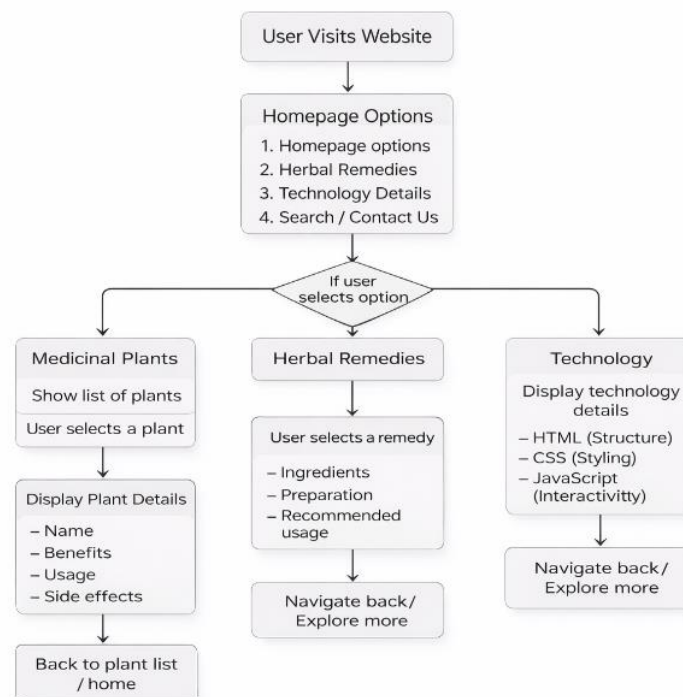


Fig.2. User Interaction Flow for the Virtual Herbal Garden Website

The flowchart (fig. 2) illustrates the user interaction flow for the *Virtual Herbal Garden*—an interactive and educational web-based system designed to help users explore the rich variety of medicinal plants used in the AYUSH systems.

## A. User Visits the Website

- The user starts by visiting the Virtual Herbal Garden homepage.
- The interface is designed to be interactive and visually appealing, welcoming users to explore medicinal knowledge in a virtual format.

## B. Homepage Options

The homepage presents four main options, each leading to a different section of the platform:

1. Medicinal Plants – View and explore various plants used in AYUSH systems.
2. Herbal Remedies – Learn about natural formulations and their health benefits.
3. Technology Details – Understand the technical architecture and tools behind the system.
4. Search / Contact Us – Search for specific plants or remedies, or reach out for more information.

## C. Selection and Navigation

- Once the user selects an option, the system routes them to the corresponding module.
- The interface supports smooth navigation, allowing users to return to the homepage or move to other sections effortlessly.

## D. Medicinal Plants Module

- Displays a list of plants categorized by their medicinal use or AYUSH system.
- When a user selects a specific plant, the system presents comprehensive details such as:
  - Name: Scientific and common names of the plant.
  - Benefits: Major therapeutic uses and health impacts.
  - Usage: Traditional and modern applications in medicine.
  - Side Effects: Any known precautions or adverse reactions.
- After reviewing, users can return to the plant list or navigate back to the homepage.

## E. Herbal Remedies Module

- Displays a list of herbal remedies derived from traditional AYUSH practices.
- When a user selects a remedy, details are shown including:
  - Ingredients: Key herbal components.
  - Preparation: Step-by-step method to prepare the remedy.
  - Recommended Usage: Dosage and instructions for effective use.
- Users can navigate back or explore additional remedies.

## F. Technology Details Module

- Provides insight into the technological foundation of the Virtual Herbal Garden:
  - HTML: Defines the structure and layout of web pages.
  - CSS: Handles styling, colors, and design aesthetics.
  - JavaScript: Adds interactivity and dynamic features to the interface.
- This module helps technically inclined users understand the development stack used to create the system.

## G. User Experience and Navigation

- Every section ensures a seamless user experience with simple navigation options like “Back to Home” or “Explore More.”
- The design ensures interactivity, accessibility, and engagement, making the exploration of herbal knowledge both educational and enjoyable.

## 5. Results

The evaluation of the web-based Virtual Herbal Garden website was carried out to measure its effectiveness in providing an interactive, educational, and immersive experience for users learning about medicinal plants from the AYUSH systems, including Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homeopathy. The study involved 50 participants, aged 18 to 55, comprising students, educators, and healthcare practitioners to represent a diverse user base. Testing occurred over a four-week period, with each participant engaging in a 15-minute session exploring features like 3D plant models, virtual tours, and quizzes. A mixed-methods approach was used, incorporating quantitative metrics such as knowledge quizzes, usability scales, and engagement tracking, alongside qualitative feedback from post-session surveys. The results demonstrate strong performance in key areas, affirming the website’s potential as an accessible tool for AYUSH education.

Knowledge retention was gauged through a standardized 10-question multiple-choice quiz administered before and after the session. The quiz focused on essential AYUSH plant information, such as properties, therapeutic uses, and cultivation details for plants like Tulsi and Aloe Vera. Pre-session scores averaged 45%, reflecting a baseline of moderate familiarity among participants. Following interaction with the website, post-session scores rose to an average of 77%, indicating a 32% improvement.

Usability was assessed using a 10-item questionnaire rated on a 0-100 scale, where higher scores denote better ease of use and satisfaction. Participants completed this immediately after their session, providing insights into navigation, interface intuitiveness, and overall experience. The average score was 82, placing the website in the excellent category based on standard benchmarks. Users praised the responsive design, noting how the layout adapted seamlessly across devices, from laptops to smartphones

Open-ended survey responses provided richer insights into user experiences. A majority (85%) described the 3D models as highly beneficial for visualizing plant details that text alone could not convey, such as leaf textures or growth patterns. Quizzes were favored by 78% for their immediate feedback, which reinforced learning in an engaging way.

The results collectively demonstrate the Virtual Herbal Garden’s efficacy as an educational tool, with marked improvements in knowledge, usability, and engagement. The 32% retention boost and high interaction rates validate the integration of 3D rendering and dynamic interfaces, making AYUSH plant knowledge more accessible and memorable. While minor issues like mobile latency were noted, the overwhelmingly positive feedback positions the website as a valuable resource for bridging traditional medicine with modern technology. These findings, gathered through rigorous testing, provide a solid basis for scaling the platform and incorporating user suggestions in future updates.

## 6. Conclusion

This paper presented the design and implementation of a web-based Virtual Herbal Garden that enhances the accessibility and understanding of AYUSH medicinal knowledge through immersive 3D visualization and interactive web technologies. By integrating Three.js-driven environments with a scalable backend and curated datasets from sources such as IMPPAT and CCRAS, the system overcomes the limitations of static repositories and delivers an engaging, user-centric learning experience. The proposed platform demonstrates how traditional herbal knowledge can be effectively preserved and disseminated using modern digital frameworks, particularly for users with limited exposure to AYUSH practices. In future extensions, the system can be enriched with real-time AR-based plant identification, AI-powered personalization, and multilingual voice-assisted interfaces, enabling deeper engagement, wider accessibility, and more adaptive learning experiences across diverse user communities.

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