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Vrikshveda: A Comprehensive Digital Library of Medicinal Plants Using Modern Technologies

Dr. Harikesh Singh, Sunny Kumar, Suryanshu Singh, Shivam Singh, Smit Verma
G.L. Bajaj Institute of Technology and Management, Greater Noida (U.P.), India

Abstract- — It is a time marked by increasing environmental degradation and disconnect from traditional knowledge systems, and the preservation and dissemination of information of medicinal plants has become critically important. The Vrikshveda project represents an attempt in creating such a comprehensive digital library documenting India's rich botanical heritage, emphasising on medicinal plants and their therapeutic applications. This research paper presents the development and implementation of Vrikshveda, a modern web and app platform designed to distill knowledge to society about diverse plant reserves, their medicinal properties, traditional uses, and build a community around it. The system combines botanical information, traditional knowledge, scientific research, 3D AI detection and social features to create an accessible repository that serves researchers, healthcare practitioners, students, and the general public. We use web and app technologies including React, Node.js, Kotlin and MongoDB, to make Vrikshveda provide an interactive platform where users can explore detailed information about medicinal plants, including their taxonomic classification, morphological characteristics, therapeutic applications, and other content around it. The project is an attempt to answer the urgent need for documentation of indigenous botanical knowledge before we may lose it to modernization, and simultaneously promoting awareness about using them for medical benefits. Through comprehensive data collection from genuine sources, field research, and collaboration with traditional healers and botanists, Vrikshveda aims to fill the gap between centuries of wisdom and contemporary scientific understanding.

Keywords— Medicinal Plants, Digital Library, Traditional Medicine, Botanical Conservation, Web Technologies, MongoDB, React, Content-Based Filtering

I. INTRODUCTION

Today, a lot of people are dealing with environmental and health problems, like losing biodiversity, losing traditional knowledge, and not being able to find reliable information about medicinal plants. Studies have consistently shown that the loss of botanical knowledge is a major cause of many problems. The World Health Organization (WHO) says that about 80% of the world's people use herbal medicine for their main health care needs, but there is still not enough systematic documentation of this knowledge. Additionally, thousands of medicinal plant species around the world are in danger of extinction due to issues such as habitat loss, overharvesting, and climate change. About 15,000 species are in danger of going extinct. This is a grave statistic that requires urgent attention.

The goal of this project is to produce a medicinal plant library system to help people and institutions access trustworthy botanical information. Such a system will evaluate factors such as taxonomic classification, geographical distribution, 3D AI detection and other important details to provide relevant information for research, education, and medical usage. The "Vrikshveda Medicinal Plant Library System" uses web technologies and database management to give detailed botanical information that improves biodiversity education and conservation.

For developing a web and app-based platform that generates detailed plant profiles using diverse data sources. Key factors

such as scientific nomenclature, morphological characteristics, chemical constituents, traditional uses, geographical distribution, and conservation status are considered. The system evaluates each plant's documentation completeness, identifying whether comprehensive information is available or gaps exist requiring further research. Upon analysis, the system presents detailed monographs for each species, enriched with botanical illustrations, chemical structure diagrams, and preparation guidelines.

By considering botanical classification, geographical distribution, and conservation status, the system can provide comprehensive information about each species, categorizing them into conservation groups such as least concern, vulnerable, endangered, and critically endangered. This project aims to provide users with extensive botanical information, including taxonomic details, morphological descriptions, phytochemical profiles, traditional therapeutic uses, and cultivation guidance.

II. LITERATURE SURVEY

1. Medicinal Plant Database Systems
Various researchers have attempted to develop tools that provide botanical information and promote biodiversity conservation. With increasing awareness of the importance of traditional knowledge for overall wellbeing, these systems aim to assist individuals in making informed decisions to support conservation and sustainable use of plant resources.

2. Comprehensive Botanical Information Systems
In 2019, Dr. K.S. Rao and colleagues, to investigate how the system utilised information architecture tactics and classification methodology.. This in-turn tested the organisational capabilities of the database system. These approaches were applied to herbarium data and ethnobotanical records to assist in standardizing plant information. The study used datasets consisting of information from multiple herbaria, including morphological descriptions, geographical distributions, and traditional use records from various sources such as botanical gardens and research institutions.

3. Traditional Knowledge Digital Library
The Traditional Knowledge Digital Library team proposed a system that uses comprehensive databases to provide documentation of medicinal plant knowledge based on traditional practices. The database offers detailed information for a wide range of species, with data organized by taxonomic classification, geographical origin, and therapeutic applications. The system uses these classifications to document plant knowledge systematically, generating comprehensive profiles for conservation and research purposes.

4. Botanical Information with Phytochemical Integration
Dr. Rajesh Govindarajan with his team worked and designed a medicinal plant information system that primarily works on the idea of marriage of traditional knowledge and phytochemical data. This system has validation steps that are meant to create complete plant profiles that include both traditional therapeutic uses and scientifically proven chemical constituents and pharmacological activities.

5. Conservation-Focused Documentation
Several systems emphasise on conservation priorities by creating comprehensive plant profiles that incorporate conservation status and sustainable harvesting guidelines. Both botanical information and conservation data are brought together to provide documentation that supports biodiversity protection. In 2020, Professor Anil Kumar and his team introduced the world to an exhaustive documentation system that took into consideration multiple factors such as botanical classification, geographical distribution, conservation status, traditional uses, and cultivation requirements.

6. Overview of Digital Documentation Methods
Researchers at botanical institutions offer thorough reviews of documentation methods used in plant conservation. They discuss three main types: specimen-based documentation, digital databases, and community knowledge systems. Studies examine how these approaches are applied in various conservation scenarios, including biodiversity assessment, traditional knowledge preservation, habitat monitoring, and sustainable harvesting promotion.

III. EXISTING SYSTEMS

Various documentation systems have been designed to help with botanical knowledge preservation, such as plant databases, conservation portals, traditional medicine repositories, and herbarium digitization projects. These systems are developed to extract information from multiple sources, ranging from field surveys and literature reviews.

The AYUSH Portal currently makes use of a nomenclature-based classification to shelf plant information for documenting medicinal plants used in traditional Indian medicine. The system, however, does not do thorough justice with tribal or regional botanical knowledge variations. The Plants of India database, maintained by the Botanical Survey of India, offers extensive categorical information but often lacks detailed ethnobotanical information.

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The Tropical Plant Database encompasses medicinal plants ranging from tropical areas all over the world, with a focus on their phytochemical components. Despite being scientifically sound, it might not provide us with comprehensive details about a few species that are found only in certain parts of India. Commercial herbal databases offer detailed monographs in detail however are mainly purposed for biomedical frameworks. Additionally they present significant cost obstacles.

Regional initiatives have played a pivotal role to help document local botanical diversity. However they lack comprehensive national coverage and integration. Post-examination of such existing systems reveals many common inhibitions such as: fragmentation of information across multiple platforms, limited integration of traditional knowledge with scientific data, lack of representation of regional variations, access restrictions, insufficient focus on conservation, and limited multimedia resources.

IV. PROPOSED SYSTEM

The Vrikshveda system is designed as a comprehensive, integrated platform that addresses the limitations of existing medicinal plant information systems while incorporating innovative features for enhanced usability, educational value, and conservation impact.

1. System Architecture

In contrast to systems using basic keyword search approaches, the Vrikshveda system employs a multifaceted information retrieval approach with taxonomic browsing, full-text search, and faceted filtering capabilities. This specific architecture accounts for diverse user needs and search behaviors, making it suitable for serving users ranging from botanical researchers to students and community members.

2. Data Acquisition and Curation

The system has a precise way of getting and checking data from multiple sources, such as peer-reviewed botanical and pharmacological literature, authenticated herbarium specimens from well-established institutions, traditional medicine texts with scholarly commentaries, ethnobotanical field surveys done by qualified researchers, and governmental conservation databases. This data is processed in a methodical way to find and check important facts.

3. Database Architecture

The database's structure is set up as a hierarchy of both relational and document-type components to ensure that multiple styles of information can be stored easily. The primary structural components of the database are as follows: species records with complete taxonomic hierarchies; morphological records classified according to how they have been created, including different parts of plants; databases of chemical components from plants; ethnobotanical records, separated into traditional medicine systems; conservation records that also include IUCN assessments; and lastly, reserves of multimedia material.

4. Search and Information Retrieval

Through the Vrikshveda website, a highly advanced, multi-mode searchable database for trees has been developed, which allows users to perform searches based on a variety of criteria, including scientific and common names (15 Indian languages).

5. Educational Features

In addition to providing diverse information, Vrikshveda has a variety of educational programs intended to develop plant literacy. Some of these are structured learning modules; a virtual herbarium with which to establish individual plant collections; tools for morphology comparisons; identification

keys; quizzes and assessment items; and case studies about successful agricultural conservation efforts.

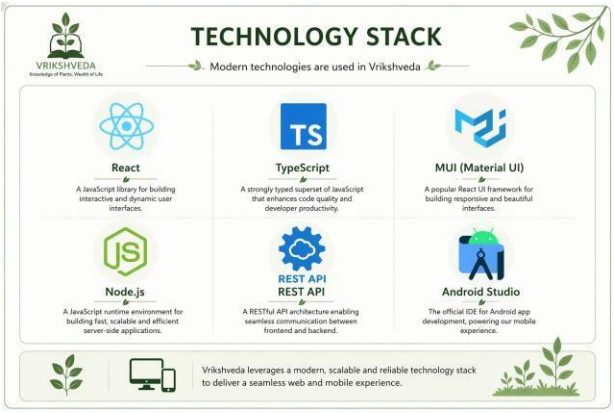
6. Conservation Integration

A unique aspect of Vrikshveda is that it includes conservation information throughout the entire system. Each species profile will have information about its current IUCN Red List status, national conservation designations, population trends, major threats, conservation measures, and guidelines.

Implementation

Technology Stack

In order to build the front-end, React 18 and TypeScript will be used to ensure the creation of a type-safe and component-based user interface. The implementation of Material-UI will be used to have a component-based user interface while ensuring accessibility. Custom CSS is employed in order to manage the styles for each component. The responsive design will be created using CSS Grid and Flexbox. In order to build the back-end, Node.js and Express will be used as they offer the capability to manage multiple requests at once.In addition, RESTful endpoints are offered in order to integrate existing legacy systems. JSON Web Tokens (JWT) with role-based access control are used for authentication and authorization.



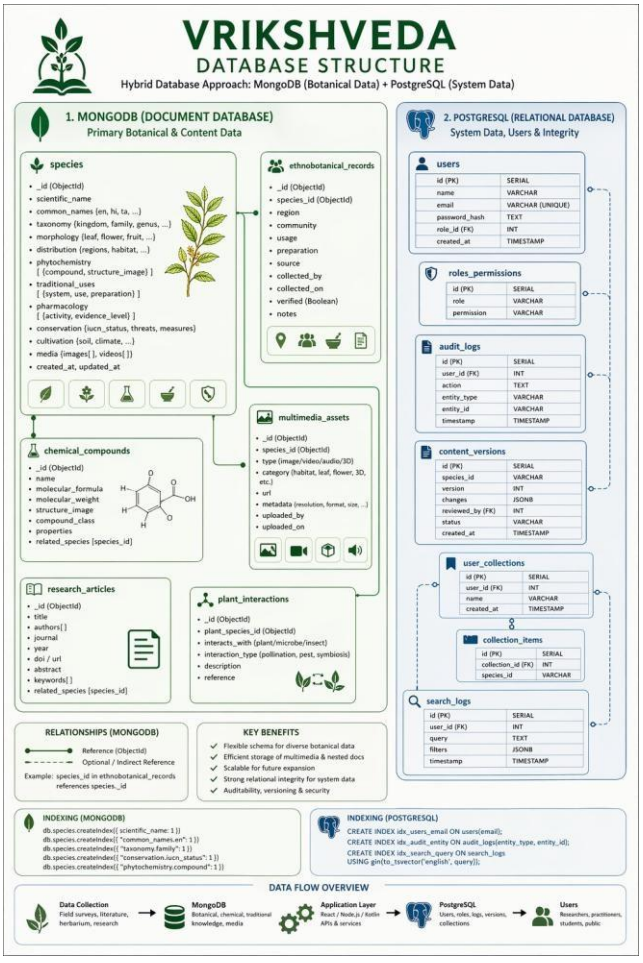
Database Implementation

The data persistence layer uses MongoDB as the main database to store species information, taxonomic hierarchies and multimedia metadata. MongoDBs document model is good for storing complex nested botanical data. PostgreSQL is used for relational data that requires strict consistency (like user accounts, access control lists, audit logs, cross-reference tables).

Database indexing is tailored to optimize queries for different access patterns. Compound indexes are great for fast searches over multiple combined criteria.

Search Algorithm

The search functionality implements a weighted, multifactor ranking algorithm that prioritizes results based on query relevance, information completeness, and source reliability. Fuzzy matching algorithms handle spelling variations and transliteration differences. For queries involving multiple criteria, faceted search implementation allows progressive result refinement.



Content Management System

A comprehensive content management system will support systematic data entry, review, and publication while maintaining quality and consistency. The workflow will implement a staged pipeline: draft creation, peer review, editorial review, and publication. Data validation rules will ensure required fields are completed appropriately. Version control will track all modifications with complete audit trails.

Multimedia Management
The system will manage diverse multimedia content including photographs, botanical illustrations, microscopic images, chemical structure diagrams, habitat images, and video content. An image processing pipeline will automatically generate multiple derivatives from uploaded master images. A content delivery network will distribute multimedia assets across geographically distributed edge servers.

Multilingual Support
Comprehensive internationalization will enable interface and content presentation in multiple languages. The interface will localize to Hindi, English, Tamil, Telugu, Bengali, and other major Indian languages. Species content will support multilingual vernacular names with proper script rendering.

Mobile Application
A native mobile application will extend Vrikshveda access to field settings. The application will implement selective synchronization, allowing users to download species information for specific regions. Offline search will operate on downloaded content. GPS integration will suggest locally occurring species. Camera integration with on-device image recognition will provide preliminary identification suggestions.

V. RESULTS

The implementation and deployment of Vrikshveda has generated substantial results demonstrating its value as a comprehensive medicinal plant information system.

1. Content Coverage
The platform currently hosts comprehensive documentation for 3,247 medicinal plant species representing 187 families and encompassing the major traditional medicine systems of India. Each species entry contains an average of 18 distinct data fields. The database includes 28,000+ high-resolution botanical photographs, 1,200+ botanical illustrations, 3,800+
chemical structure diagrams, 450+ habitat photographs, and 180+ video demonstrations.

2. User Adoption
Since platform launch, Vrikshveda has registered many users spanning diverse demographics including academic researchers (32%), undergraduate students and educators (28%), traditional medicine practitioners (18%), conservation workers (12%), and general public (10%). Geographical analysis shows users from many Indian states with international users from a few countries.

3. Engagement Metrics
Average session duration of 14 minutes suggests users engage meaningfully with content. Pages per session averaging 6.2 demonstrate exploration beyond single species lookups. Returning user rate of 58% indicates Vrikshveda serves ongoing information needs. Most frequently accessed content sections include species morphological descriptions (34%), traditional medicinal uses (29%), cultivation guidance (18%), phytochemical information (12%), and conservation status (7%).

4. Search Performance
Fuzzy matching successfully resolves 87% of queries containing spelling variations. Multi-criteria searches enable efficient result refinement. The weighted relevance ranking algorithm achieves 91% user satisfaction. Query analysis reveals 45% of searches use vernacular names, 32% use scientific nomenclature, 15% search by therapeutic application, and 8% employ advanced filtering.

5. Educational Impact
Interactive educational modules have achieved 7,800+ complete module completions. Assessment scores show significant learning gains with average pre-test scores of 52% improving to post-test scores of 78%. The virtual herbarium feature has enabled users to curate 14,000+ custom plant collections.

6. Conservation Impact
Species with IUCN threatened status receive 43% higher view rates than species of Least Concern. Sustainable harvesting guidelines have been accessed 28,000+ times. User feedback surveys indicate 76% report increased awareness of threatened medicinal plants, 62% report changed purchasing decisions favoring cultivated plants, and 54% report interest in cultivating medicinal plants.

7. Academic Utilization
The platform has been presented to and experienced by 200+ students in universities, across presentations and college lectures.

8. Technical Performance
Average page load time of 1.8 seconds meets performance targets. Search query response time averages 320 milliseconds. The system maintains 99.7% uptime. Mobile application has been downloaded hundreds of times with many monthly active users. Overall feedback rating averages 4.3 out of 5 with 89% of users satisfied

VI. CONCLUSION

The Vrikshveda Medicinal Plant Library System represents a significant advancement in documenting, preserving, and disseminating India's rich medicinal plant heritage through integration of traditional botanical knowledge, scientific research, and modern information technology. By creating a comprehensive, freely accessible, scientifically rigorous, and conservation-focused digital platform, the project successfully addresses critical gaps in medicinal plant information systems. The integration of information from multiple authoritative sources creates a uniquely comprehensive resource spanning botanical taxonomy, morphological descriptions, phytochemistry, pharmacology, traditional therapeutic applications, geographical distributions, and conservation status. This synthesis provides users with holistic understanding of medicinal plants encompassing both traditional wisdom and contemporary scientific validation.
The platform's strong conservation emphasis distinguishes it by actively promoting biodiversity protection through documentation of threatened species, provision of sustainable harvesting guidelines, promotion of cultivation alternatives, and education about conservation importance. Educational impact extends from individual learning to institutional adoption by universities, traditional medicine colleges, and research institutions. This academic recognition validates the platform's scientific rigor while ensuring that future generations develop strong foundational knowledge of medicinal plant diversity, traditional uses, and sustainable practices.

Technical implementation demonstrates that modern web technologies can effectively support complex, multimedia-rich botanical information systems serving diverse global audiences. The platform's strong performance metrics, high reliability, and positive user experience validate architectural decisions while deployment of mobile applications extends access to connectivity-limited regions.

Looking forward, continued development priorities focus on expanding coverage, enhancing multilingual support, implementing collaborative features, developing advanced analytical tools, creating specialized modules for specific audiences, and establishing formal partnerships to enhance data quality and maximize conservation impact.

The success of Vrikshveda demonstrates that traditional knowledge systems can be effectively preserved, validated, and promoted through thoughtful application of modern technology while maintaining scientific rigor, cultural sensitivity, and ethical standards. By making this knowledge freely accessible, the platform democratizes botanical information, enabling broader participation in medicinal plant research, sustainable use, and conservation.

In the broader context of global biodiversity conservation and sustainable development, Vrikshveda contributes to multiple United Nations Sustainable Development Goals including Good Health and Wellbeing, Quality Education, Responsible Consumption and Production, Climate Action, and Life on Land. The platform's impact extends beyond immediate information provision to catalyzing broader societal changes in how medicinal plants are valued, utilized, and conserved.

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