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Development of or Code-Based Tree Species Identification System at Soil Conservation Training School, Miran Sahib, Jammu

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Abstract
Trees provide numerous benefits to humans and other living organisms, making accurate tree species identification essential for their management and conservation. Identifying and describing tree species is also critical for genetic studies, biodiversity conservation, management practices, and regeneration strategies. Traditional methods of tree identification are often time-consuming and require significant expertise, highlighting the need for more efficient approaches. This research focuses on developing a QR code-based system for tree identification. Tree data were collected from Soil Conservation training School Miran Sahib. The system was designed using a three-tier architectural model. The database system, built with MS Word, formed the base tier. The middle tier, comprising the google drive, was employed as the scripting language to interact with the database. The client tier was developed Word file converted to PDF format. The QR code generator, ME QR an open-source software, utilized a QR code library to create QR code images. Each QR code was linked to a google drive database containing detailed information about tree species. These QR codes were attached to trees, allowing users to scan them and automatically access the corresponding tree information on the website. A user survey conducted at the study site showed that the QR codes were user-friendly and made tree identification more engaging. The system increased public knowledge about trees and demonstrated potential for improving tree management practices.

Keywords: QR code, Tree identification, ME QR, GIS, ICT, Soil Conservation Training School, Forest management, know your tree, know your campus, ceremonial plantation, transport layer system

1. Introduction

Sub-tropical forests are home to an extraordinary diversity of tree species, with estimates suggesting that a single hectare may contain between 100 and 300 different species [1, 2, 3]. Each tree species holds unique ecological, economic, and cultural value, but identifying and understanding these species can be challenging due to their sheer variety. For laypersons and tourists, engaging with this rich biodiversity often feels daunting.

Information and Communication Technology (ICT) has transformed various fields, including forestry, by improving forest monitoring, accessibility of information, and public engagement [4]. Tools like Remote Sensing and Geographic Information Systems (GIS) have played crucial roles in forest management and resource mapping, supporting sustainable practices and long-term ecosystem health [5].

This study introduces the "Know Your Trees" platform, which utilizes Quick Response (QR) codes to simplify and enhance tree identification in forests, specifically in Jammu and Kashmir. A QR code, a two-dimensional matrix code, stores large amounts of encoded data, such as text and URLs, and offers several advantages over traditional barcodes [6, 7]. These include higher data capacity, dirt and damage resistance, omnidirectional readability, and error correction. QR codes remain functional even if partially damaged, making them suitable for fast-paced, real-world applications [8].

Fig 1: Trees in open spaces, such as university campuses

The platform was designed to provide real-time, on-the-go access to tree species information, bridging the gap between complex taxonomy and user-friendly interaction. Unlike existing solutions like PlantNet, PictureThis, and iNaturalist, which cater to broader or gardening-specific identification, Know Your Trees focuses on trees in open spaces, such as university campuses, training Institutes, parks and gardens ensuring tailored and reliable data collection.

2. Literature Review

The integration of ICT in tree identification has gained attention in recent years. For instance, Reference [9] developed a mobile plant tagging system for urban forest ecotourism in Malaysia, enhancing visitor experiences by enabling quick access to plant information. Barcodes and QR codes have emerged as popular tools for making tree identification more interactive and accessible [9, 10, 11]. Unlike traditional methods requiring taxonomical expertise and reference books, QR codes allow users to retrieve tree information independently and conveniently. In Saudi Arabia, QR codes have been used in religious tourism to provide visitors with instant access to relevant information [12]. Similarly, Reference [9] implemented a tree-tagging system at University Putra Malaysia's Sultan Idris Shah Forest Education Center, enabling visitors to explore plant data using their mobile devices. Jammu University and Shri Mata Vaishnodevi University recently have developed QR codes for the in-campus tree species. Jammu and Kashmir Forest Research Institute has geotagged the heritage trees along with QR code.

In the study area, tree identification is primarily conducted manually, which is time-consuming and requires expertise, making it inaccessible to the general public [13]. This study addresses the gap by introducing an ICT-based QR code system that simplifies tree identification, making it user-friendly, engaging, and efficient. This approach not only democratizes access to information but also promotes tree conservation and management through enhanced public understanding and interaction. Soil Conservation Training School Miran Sahib trains in- service forest officers, tree identification is a part of their syllabus, identification using the traditional methods requires a lot of skills, it is therefore they are trained to develop the QR code of the campus diversity, so that they could develop the QR codes in their respective forest divisions.

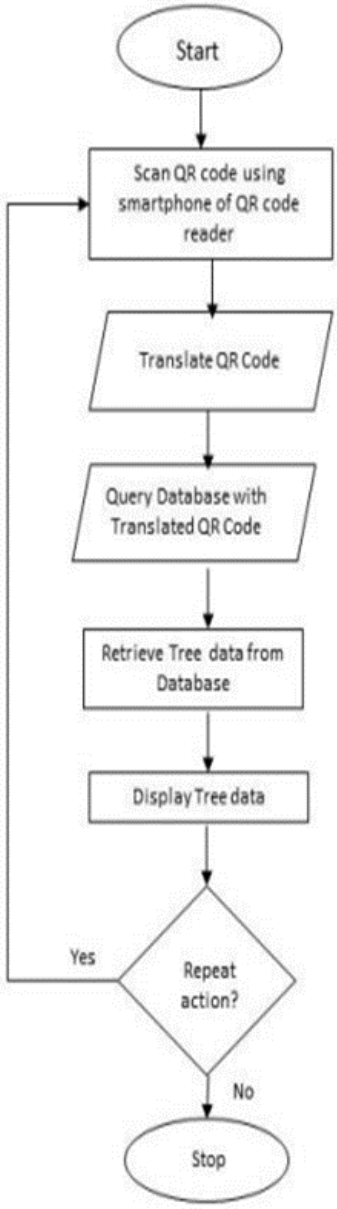

Fig 2: System Flow Chart

3. Methodology

3.1 Study Area

The research was conducted at Soil Conservation training School Miran Sahib. The institution was selected for their academic focus on forestry, as well as their rich variety of tree species. Beyond the academic roles, the campus serves as thriving ecosystems, making them ideal for this study. The ultimate goal is to extend the scope of this project to other parts of Jammu and Kashmir.

The Soil Conservation Training School Miran Sahib was established during the year 1960-61 with the objective to train in-service foresters on soil conservation. Later on, the department started Kashmir Foresters Training programme at Soil Conservation Training School. At present 24th batch of KFC training comprising of 35 trainees from across the Union Territory of Jammu and Kashmir is undergoing. The trainees were firstly trained on tree identification using traditional methods and later on the were assigned the task of data collection for each tree species growing in the campus. The trainees collected the data by using random sampling and

complete enumeration methods. The trainees were familiarized with use of GPS, different methods of spatial data collection, processing the collected data with Google Earth Pro platform and GIS environment. Use of laser range finder and different mobile based applications for the data collection. The data collected by using GPS and Range Finder were corelated with the data collected using different mobile applications, so that the reliability of collected data is to be established. A hands-on training was organized for the creation of QR codes using open-source applications so that every trainee could be able to create the QR code at his own in his respective places of posting after passing out from the Soil Conservation Training School Miran Sahib. The trainees were asked to create QR code for the ceremonial plantations. The ceremonial plantation QR code was integrated with the detail of the event as well as the photographs of the dignitaries of the event. Similarly, the trainees created QR codes under Know Your Campus, which provides the details about the Soil Conservation Training School Miran Sahib.

Fig 3: Developing a comprehensive tree database tailored to the QR code system

3.2. Data Collection

Data collection involved an initial survey of campus to familiarize the research team with the campus' layout, including road networks and tree distribution. This survey also helped identify specific areas for focused data collection. Tree species data—including botanical names, common names, and family names—were gathered with the help of an experienced Instructor. Additional information, such as the uses, distribution, and habitat of each species, was sourced from existing literature and other references. This combination of field observations and literature review formed the basis for developing a comprehensive tree database tailored to the QR code system.

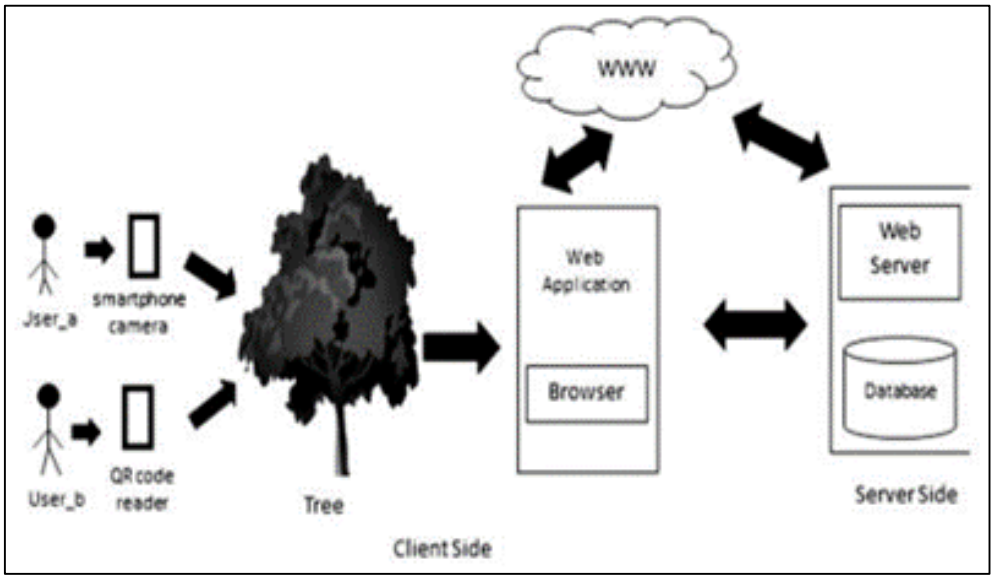

Fig 4: Database was designed to include essential data such as species name, family, local names, descriptions, and uses

3.3 Database Structure

The tree information database was designed to include essential data such as species name, family, local names, descriptions, and uses. Complementary data, such as photographs and tree position coordinates, were also integrated, though the coordinate feature has not yet been uploaded to the platform.

The database schema was developed to organize the data efficiently, with relationships between tables established using primary and foreign keys to ensure data integrity. Key components of the database include:

- Trees Table: Stores specific information about each tree, including primary keys for unique identification. Attributes such as data name, type, length, and column constraints (e.g., "not-null") ensure the completeness and uniqueness of data entries.
- Images Table: Contains photographs associated with each tree species, linking visual data to the corresponding tree information in the database.

Table 1: Tree table structure

Column	*Datatype*	*Length*	*Constraint*
Tree_id	serial	8	Primary Key
Common Name	Varchar	30	Unique, Not null
Family Name	Varchar	30	Not null
Specie Name	Varchar	30	Not null
Location	Varchar	30	Not null
Tree Uses	Varchar	200	Not null
Distribution	Varchar	100	Not null
Other Information	Varchar	200	Not null

Table 2: Image table structure

Column	*Datatype*	*Length*	*Constraint*
Tree_id	Serial	8	Primary Key
Tree Image	Bytea	200	Unique, not null

3.4 System Architecture

The system is a drive bases application designed to receive input:

Scanning a QR code affixed to a tree using a QR reader or smartphone camera. The input method activates a scripting program that retrieves relevant tree information from the database and displays it on the screen.

Fig 5: QR codes generated for tree species such as *Araucaria hetrophylla* and *Dypele luteacene*

4. Results - System Development

4.1 QR Code Generation

QR codes were generated using Microsoft Word platform, with data such as URLs, tree information, and alphanumeric details encoded into the codes. A QR code library facilitated the creation of these codes, allowing users to specify the size and format through the PDF format. Examples of QR codes generated for tree species such as *Araucaria hetrophylla* and *Dypele luteacene* are displayed above. These QR codes, when scanned, provide instant access to the corresponding tree information stored in the database.

Fig 6: Soil Conservation

4.2 QR Code Integration

The QR code functionality was seamlessly integrated into an Open-Source ME QR Code application, ensuring secure communication between users and the server and Transport Layer Security (TLS). These measures created a safe environment for interactions.

Each tree species was assigned a unique ID number, which served as a reference for generating specific links. Scanning the QR code affixed to a tree using a mobile device would prompt a link to appear on the user's QR code scanner app. clicking the link redirected users to a dedicated PDF displaying detailed information about the tree.

The QR codes were generated using the Google Drive storage, and ME QR an open-source tool for dynamically creating customizable QR codes within PHP applications. This feature-rich library simplifies integration into web platforms, making it a preferred choice for this project.

Fig 7

4.3 User Interface Design

A user-friendly interface was developed to enable easy access to tree information. The platform included:

• Search Functionality: Allowed users to query the database using the scanned QR code.

• Intuitive Navigation: Ensured straightforward interaction for users of all levels.

4.4. Homepage Design

The homepage was designed using Word to PDF format for

the visual appeal and ease of use. When users scanned a QR code, the site automatically launched and displayed comprehensive details about the tree species, such as its common and botanical names, descriptions, and uses.

4.5. Backend Architecture

The backend, or server-side, served as the engine of the application, handling data storage, retrieval, and processing. It consisted of three key components:

1. Server: Ensured seamless communication between the database and frontend.
2. Application Logic: Managed data requests and responses.
3. Database: Google Drive, relational database management system, was selected for its performance, scalability, and support for spatial data and geolocation capabilities. To optimize performance, strategies such as content caching and lazy loading were implemented. Content caching reduced server load and response times, while lazy loading deferred the retrieval of certain elements until needed, enhancing efficiency.

4.6. Content Management System (CMS)

A CMS was integrated into the backend to allow editors to manage and update information directly within the database. This streamlined the process of maintaining accurate and up-to-date tree information. Figure 11 displays a screenshot of the Information Update Portal.

4.7. End-User Feedback Assessment

To evaluate the system's effectiveness, a sample of 40 users (5 staff and 35 students) from Soil Conservation Training School, Miran Sahib participated in an appraisal. They scanned QR codes attached to various tree species and provided feedback on their experiences.

Results revealed that

- Ease of Use: 84–92% of users found the system very easy to use, while the remaining found it somewhat easy.
- Impact: 100% of respondents agreed that the system improved accuracy in tree identification, enhanced learning, and made the process engaging.
- Familiarity: While 80–84% had prior experience using QR codes, 96–100% had never used them for tree identification before.

The unanimous positive feedback highlights the system's reliability, user-friendliness, and effectiveness, with a potential for widespread adoption.

5. Discussion

The use of QR codes, initially developed over two decades ago, has evolved into diverse applications, including marketing, education, and resource management. The integration of QR codes into forestry represents an innovative approach to natural resource management, simplifying tree identification and conservation efforts.

The QR code system developed in this study eliminates the need for time-consuming manual methods, such as consulting books or seeking expert guidance. With internet connectivity, users can access detailed tree information within five seconds by scanning a QR code, making the process fast and efficient. Similar systems deployed in Malaysia's urban forests have shown comparable benefits.

The system also provides accurate information about tree species, their uses, and their role in conservation, which can enhance user awareness and interest in tree planting. This aligns with findings that QR codes facilitate learning and improve tourism experiences by reducing reliance on tour guides and reference materials.

While highly effective, the system faces limitations, including:

- QR code degradation over time due to environmental exposure.
- Dependence on stable internet connectivity.
- Lack of access to smartphones or QR code readers for some users.

6. Conclusion

The development of a QR code system for tree identification offers a practical, cost-effective, and time-saving solution for both foresters and non-foresters. Linked to a robust database, the system provides precise information about tree species, enhancing learning, conservation, and resource management efforts.

Positive end-user feedback underscores the system's reliability and potential for broader deployment in places with similar ecological characteristics to Soil Conservation Training School, Miran Sahib

7. Future Prospects

1. AI Integration: Leveraging data from various institutions to train neural networks for improved taxonomy and analytical capabilities.
2. Enhanced Accessibility: Enabling users to query the database for tree species and their geographic locations in educational institutions across Jammu and Kashmir.

These advancements will further establish the platform as a comprehensive resource for botanical and educational insights, promoting conservation and sustainable forestry practices.

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