An ML-Powered Mobile App with Automated Identification and Multilingual Documentation of Traditional African Medicinal Plants for Preservation of Indigenous Knowledge, Biodiversity Conservation, and Community Health Improvement

BSc. in Software Engineering

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DECLARATION

This Proposal Project is my original work, unless stated, and all external sources have been referenced or cited in my document. This work has not been presented for the award of a degree or any similar purpose in any other university

Signature…C.N………………………… Date…05/26/2025…
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Abstract

African Traditional Medicine (ATM) has been a cornerstone of healthcare for generations, with over 80% of the continent's population relying on it for basic health needs. However, the disintegration of oral traditions, coupled with biodiversity loss and climate change, threatens the preservation of this invaluable knowledge. Current digital solutions for plant identification lack comprehensive coverage of African medicinal species, local language support, and detailed documentation of preparation methods. This project addresses these gaps by developing an ML-powered mobile application that automates the identification of traditional African medicinal plants and provides verified information in English and Luhya. Leveraging convolutional neural networks (CNNs) and offline-capable technologies like TensorFlow Lite, the app enables users to identify plants, access ailment-specific remedies, and contribute to a crowdsourced knowledge base. By integrating multilingual support, community verification, and conservation awareness, the solution aims to preserve indigenous knowledge, promote biodiversity conservation, and improve rural healthcare access. The app will be tested with 10 users in Bumala, Busia, Kenya, ensuring cultural relevance and usability. Upon successful implementation, this project could serve as a model for similar initiatives across Africa, fostering cross-cultural knowledge sharing and sustainable healthcare solutions.

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LIST OF ACRONYMS/ABBREVIATIONS

- ATM_African Traditional Medicine
- ML_ Machine Learning
- AI_Artificial Intelligence
- CNN_Convolutional Neural Network
- WHO_World Health Organization
- UX/UI_User Experience/ User Interface
- KEMRI_ Kenya Medical Research Institute
- CHEK_Council for Human Ecology in Kenya
- KUTMP_Kenya Union of Traditional Medicine Practitioners
- TICAH_Trust for Indigenous Culture and Health
- PROTA_ Plant Resources of Tropical Africa
- GBIF_Global Biodiversity Information Facility
- MVP_Minimum Viable Product
- IDE_Integrated Development Environment
- AWS_Amazon Web Services
- UML_Unified Modeling Language
- UCD_User-Centered Design
- API_Application Programming Interface
- CMS_Content Management System

- ★ GPS_Global Positioning System
- ★ HTTPS_Hypertext Transfer Protocol Secure
- ★ TLS_Transport Layer Security
- ★ AES-256_Advanced Encryption Standard (256-bit)

CHAPTER ONE: INTRODUCTION

1.1 Introduction and Background

On 31 August every year, WHO always marks African Traditional Medicine Day to honour the integral role of traditional medicine in the health and welfare of generations of people on the African continent. WHO recognizes that traditional medicine has been the trusted, accessible, affordable, and acceptable source of healthcare for African populations for centuries. To date, 80% of the continent's population relies on traditional medicine for their basic health needs (WHO, 2022). This percentage goes up to even 90% in some African countries. In Kenya, statistics indicate that 75 to 90 percent of local communities rely on ethnomedicine as their primary healthcare system, highlighting the importance of these resources (Ochieng Obado & Odera 1995; Sindiga et al. 1995).

For decades, even before colonization, Africans have been using more than 5,000 traditional medicinal plants to treat various illnesses/health problems(Makunga,2022). These solutions have been passed down from one generation to another via observation and storytelling, which was made possible by the close-knit communities we had back then. In the modern world, the disintegration of community and the triple planetary crisis: climate change, pollution, and biodiversity loss have since threatened the loss of this precious ethnobotanical knowledge and plants. It is estimated that by 2100, climate change alone could cause the loss of over half of African bird and mammal species, as well as trigger a 20%–30% decline in lake productivity (the plant and animal life produced by a lake), and a significant loss of plant species(World Bank Group, 2019). Medicinal plant resources in Kenya are diminishing at an alarming rate due to unsustainable harvesting practices and the destruction of plant habitats(Gakuya et al., 2020).

African traditional medicine knowledge is often informal and undocumented, yet there are so many herbs that make the traditional approach of passing down the knowledge by word of mouth unsustainable. Efforts to document have been seen in the recent past through academic publications, government reports, and community-based initiatives/NGOs. Government institutions include KEMRI, the National Museums of Kenya, and the Ministry of Health. Universities like Moi, Kenyatta University, and the University of Nairobi have repositories containing research papers and theses on ethnomedicine, not forgetting journals in academia like the Journal of Ethnopharmacology, the African Journal of Traditional, Complementary, and Alternative Medicines, and the Kenya Journal of Herbal Medicine. Various books on traditional medicine have been published by kenyan authors; examples are: "Medicinal Plants of East Africa" by John Kokwaro, "Traditional Medicinal Plants in Kenya" by Patrick Maundu et al, and "Herbal Medicine in Kenya: A Guide to Common Medicinal Plants" (various authors). NGOs such as the Council for Human Ecology in Kenya (CHEK) have developed a handbook in which it has indexed 42 plants (herbs) claimed to be medicinal, in the Bukusu community of western Kenya and a business called Umai Naturals has also published a handbook for traditional medicine majorly used in the kikuyu community. Kenya Union of Traditional Medicine Practitioners(KUTMP) passes down indigenous knowledge through workshops. Lastly, digital archives and online databases like TICAH (Trust for Indigenous Culture and Health), PROTA (Plant Resources of Tropical Africa), and Global Biodiversity Information Facility (GBIF), among others, contain information on indigenous knowledge in Sub-Saharan Africa. Most recent forms of passing ATM are web and mobile applications as well as social media platforms, especially TikTok and YouTube.

A journal by BMJ Global Health highlights that the results of many literature reviews reported adverse drug reactions of herbal remedies are often due to a lack of understanding of their preparation and appropriate use(Mutombo et al., 2023), underscoring the need for documentation. There is without doubt that with information and knowledge comes the zeal to conserve and preserve, hence a call to all stakeholders to ensure African traditional medicine knowledge is properly documented for generations to come. Hence, on this proposal, we are going to zoom in on the use of machine learning to make this a reality.

1.2 Problem Statement

Machine learning has evolved over the years, and it has recently found itself in applications such as the identification and documentation of African traditional medicines. It is important to note that the automated identification of plants began with general plant species as a whole, and its use in medicinal plants came about through continued research and interest in the ATM topic. Previously, species were identified by leaves predominantly, but over time, multi-organ-based plant identification emerged. (Waldchen et al., 2018), In his paper explores the pla@ntNET, PlantSnap, and iNaturalist app that is available on the web, mobile, and app store, where people can identify plant species and also contribute pictures to enhance the model. Limitations, however, are that they are not suited to African traditional medicinal plants, contain few species local to the African continent, and only employ English. (Pl@ntNet, 2019; INaturalist, n.d.).

Medicinal plant identifier, made by a Cameroonian (Yacynth Ndonna, n.d), has 90% accuracy in identifying plants, mushrooms, and flowers in a herb garden. The plant menu details the virtues, scientific names, chemical compounds, and how to use plants to have natural healing remedies. The Diseases and advice menu brings together grandmother's homemade recipes and quick natural treatments, well verified by several patients. The benefit and virtue menu contains information on how to make herbal teas and home treatments. The pharmacy menu includes natural products made in aromatherapy and phytotherapy by natural health experts and herbalists with Ayurvedic herbs. The Forum menu is a space for exchange, debate, and discussion between forum members, doctors of natural medicine, naturopaths, and herbalists. The Video menu explains in more detail the plants, herbs, barks, and spices with medicinal virtues.

(Kumar et al., 2012) and other journals highlight how using leaves for identification in the machine learning models proved efficient. The paper also showcases the success of the Leafsnap mobile app, attributing it to the use of colour-based segmentation, the possibility of crowdsourcing for data with verification labels, mapping GPS coordinates and timestamps to crowdsourced data to map biodiversity regions. However, the app identifies general plant species and is not niche to medicinal plants, but we can borrow some ideas. It is also important to note that the app is based in the Northeastern United States and Canada only.

MedicPlant identifies medicinal plants in the Republic of Mauritius using a deep learning architecture and can work offline without an internet connection, with no pre-processing steps. The model used to build the app uses more classes, hence any part of the plant can be taken. However, the mobile app lacks an extensive information display once a plant is identified, as it shows only the common name of the plant, its English name, and its scientific name. It is suited for Mauritius geography only. The plant is also classified as either exotic or endemic, followed by its medicinal applications and a short description (Pudaruth et al., 2021; University of Mauritius, 2019).

Aayu mobile app uses AlexNet to identify plants and displays information on ayurvedic plants in three main Sri Lankan languages: English, Sinhala, and Tamil, uses a geolocation API to identify plant location, tests the knowledge of the user using a quiz, and gives results. However, the researchers noticed that the model didn't operate well when the leaves of the plant had diseases, hence necessitating a need for training a model that generalizes on such outliers (Dassanayake et al., 2021; Yashsoni, 2024).

1.3 Project's Main Objective

What is the overall aim of your project?

To develop an ML-powered mobile app that identifies African traditional medicinal plants and provides verified information(name, ailment treated, mode of preparation/administration) in English and Luhya in order to preserve indigenous knowledge, conserve biodiversity, and improve community health.

1.3.1 List of the specific objectives

1. To understand, review literature, collect data, and gain insight into my research topic so as to write a research proposal before 05/27/2025.
2. Develop a solution based on the insights gained from the research, starting with a Figma design and an ML model, then a finished mobile application by 06/28/2025.
3. Collect and verify results based on measurable metrics that address the gap by testing the mobile app with real users and writing a report by 07/12/2025.

1.4 Research questions

1.4.1 Main Research Question

How can machine learning be leveraged to develop a mobile application that accurately identifies African traditional medicinal plants and provides verified information (in English and Luhya) in order to preserve indigenous knowledge, conserve biodiversity, and improve community health?

1.4.2 Supporting Research Questions

1. Knowledge and documentation gap
- What are the current methods of documenting and transmitting African traditional medicine (ATM) knowledge in Kenya, and what are their limitations?
- How effective are existing digital tools in preserving and disseminating ATM knowledge in Africa?

2. Technical and machine learning considerations
- Which machine learning models (e.g., CNN, AlexNet, ResNet) are most effective for multi-organ (leaf, bark, flower) medicinal plant identification?
- How can a machine learning model be trained to account for variations in plant appearance (e.g., diseased leaves, seasonal changes)?

3. Localization and usability
- How can the app be optimized for local languages to improve accessibility for Kenyan communities?

- What features enhance user engagement and knowledge retention?

4. Conservation and community Impact
- How can the app contribute to the conservation of endangered medicinal plants in Kenya?
- What role can crowdsourcing play in improving the app's database and accuracy?

5. Validation and adoption
- How accurate is the ML model compared to existing medicinal plant identification tools
- What are the key challenges in ensuring community adoption and trust in an AI-powered ATM app?

1.5 Project Scope

1.5.1 In-Scope

- Develop an ML model for identifying African medicinal plants
- Build a mobile app with:
- - Camera-based plant ID
- - English & Luhya plant identification
- - Basic plant info (name, uses, preparation)
- - Community hub
- - Sustainability guides and blogs
- - Chatbot
- Test with real users in Bumala, Busia, Kenya
- Document findings

1.5.2 Out-of-Scope

- Medical efficacy validation
- Complete telemedicine setup
- Coverage of all African species
- Plant disease diagnosis
- Other local languages
- IoT/sensor integration

1.6 Ethical Considerations

My research project brings forth several ethical considerations, given that it deals with indigenous knowledge; hence, I will discuss how to address them below.

First and foremost, the app is meant to collect sensitive data and information like plant images submitted by users for identification, the verified images and remedies submitted in the community hub page, and geolocation data. To address data privacy issues, all data will be encrypted by the use of AES-256 for local storage and HTTPS/TLS with role-based access control for cloud transmission, and if possible, some data will be pseudonymous. All data consent protocols and compliance will be followed per Kenya's Data Protection Act, 2019 ("Data Protection Act," 2019) and the Nagoya protocol("Nagoya Protocol on Access and Benefit-sharing," 2014). A data retention policy will be implemented to delete unnecessary records periodically. Implementation of a multi-layered consent form will help users to understand how their data is used properly. Remedies submitted by traditional healers will be restricted for community use alone to avoid being commercially misused, not forgetting to conduct a Privacy Impact Assessment (PIA) before launch.

Secondly, comparative analysis of African traditional plant databases may differ from actual indigenous knowledge in the focus local community during research, which might affect backend development. Such findings will be handled sensitively and gaps addressed by the community herbalist I am working with before publishing. Anomalies identified in the community hub page during testing will be addressed through expert validation, rather than discrediting submitted data. Ethical considerations followed in the literature review for existing systems in an effort to make the Misala app unique included: avoiding direct replication of existing proprietary features, doing a balanced analysis of all the sources and not only the sources that support the research, and not misinterpreting the weaknesses of existing systems. Using platforms like iNaturalist, Google Lens, and Pl@ntNet mislabelled African medicinal plants, hence the need to train a model that is fine-tuned to the African context. Using geolocation may unintentionally cause unsustainable harvesting and bio-piracy, hence I will omit that feature for now till there is a better way to handle the particular ethical consideration.

Thirdly, building the model may borrow motivation from open-source ML models, frameworks, and algorithms on open-source platforms such as Hugging Face, Kaggle, Roboflow, and Stack Overflow. This will be addressed by documenting all external dependencies in the Google Collab notebook, reviewing third-party licenses before using the above, and ensuring full compliance with all proprietary measures. Pre-trained models that make building easier and faster, like ImageNet and inceptionv3, are optimized for plants in the Western world, which could cause bias while training my model. To address this, I will fine-tune the model using local data, and if that is not enough, I will provide a disclaimer on the app's limitations in plant identification. To counter the use of code snippets from AI tools, I will refactor borrowed code to fit the project's needs rather than using it verbatim. Users who contribute to the community hub page will be given an opportunity to consent reuse of their data. To avoid users mistrusting the app, there will be an option for reporting misidentified plants to improve the model's future performance.

The research has already been submitted to the university ethics committee, and feedback has been iteratively looped into it with the help of the capstone supervisor. I engaged the council of elders for Bujumba sub-location to secure cultural approval for the app. Before using the app in real life in the future, approval will be obtained from the Kenya Medical Research Institute (KEMRI) and the National Commission for Science, Technology and Innovation (NACOSTI) for biodiversity research. Furthermore, a partnership with the Kenya Union of Traditional Medicine Practitioners (KUTMP) will help in making the app more suitable for the intended audience. A benefit-sharing clause strictly following the Nagoya protocol will be shared by community herbalists in case the app is monetized in the future. Minors will require guardian signatures before contributing to the community hub page. All these digital consents will be logged in the mobile app backend with timestamps.

The mobile application's design and functionality must carefully avoid language, categorizations, or algorithmic outputs that could stigmatize users, misrepresent traditional knowledge, or reinforce harmful stereotypes. Terms like "invalid remedy," "incorrect plant," or "unverified healer" could undermine trust in traditional medicine systems and demoralize community contributors. If the model disproportionately misidentifies plants from marginalized regions, users might infer their flora is "less legitimate." For instance, a plant named in Luhya might be auto-corrected to a scientifically "approved" term, erasing indigenous taxonomy. Flagging user submissions as "low quality" based on technical factors such as blurry images could disproportionately affect rural users with limited tech access. These ethical considerations will be mitigated by using a neutral empowering language, allowing users to tag submissions with local names to highlight regional diversity, an override function whereby if the app mislabels a plant, users submit corrections with notes, and avoiding deficit framing. For disputed remedies, adding nuanced disclaimers like for example, ‘some healers use this for cold, but consult a clinic for diagnosis’, will make such a huge difference.

If the app is perceived as a standalone diagnostic tool, users might bypass healers, threatening their livelihoods and devaluing decades of oral knowledge transmission. Instead, the app will be positioned as a complementary tool where users are referred to healers via a telemedicine tool, with profiles of registered herbalists, a feature to be added in the future. Uncompensated crowdsourcing of remedies could enable biopiracy or commercial misuse by third parties like pharmaceutical companies. Mitigation will look like having benefit-sharing agreements, tagging user-submitted knowledge with Traditional Knowledge (TK) labels, and uploading remedies to open-access databases to prevent patenting by outsiders. Tech-savvy younger users might monopolize the app’s benefits, sidelining older healers who lack digital literacy. Addressing this risk is by enabling offline access, which is a feature in the Misala App, and using digital ambassadors. If the app is monetized in the future, transparent revenue models and community equity models will help uphold employment/social standing.

The development of the Misala app will involve navigating culturally sensitive knowledge, health-related risks, and potential ethical pitfalls tied to misinformation or misuse. If the app displays high confidence in incorrect plant IDs, users may trust it blindly, leading to harmful misuse like poisoning from misidentified toxic plants and overpromising efficacy. For instance, claims that a plant could cure malaria could discourage users from seeking clinical care. This will be addressed by displaying the confidence score while identifying plants and replacing 'treats X disease' with 'traditionally used for X symptoms'.Remedies for stigmatized conditions like HIV, STIs, and infertility could expose users to discrimination if linked to their profiles. Instead, search items tied to user IDs will not be stored, and sensitive data should only be locally processed. Some plants have sacred or ritual uses, publicizing these could lead to violation of cultural secrecy and misuse by outsiders; hence, such data will be handled with caution.

Finally, the project will adhere to local guidelines like Kenya's Traditional Health Practitioners Act (KENYA LAW, 2022) and international standards like WHO's ethical framework for traditional medicine research (PAHO, 2000; WHO, 2024). The Nagoya Protocol mandates prior informed consent and benefit-sharing mechanisms for traditional knowledge, requiring collaboration with community elders and documentation through blockchain-based systems. A phased implementation approach will begin with regulatory mapping and pilot testing in Busia County before scaling. The solution will grow to address cross-border data flows using African-based servers while maintaining flexibility for evolving regulations through quarterly policy reviews. Critical future steps involve hiring specialized legal counsel on a contract basis, developing compliance automation tools, and conducting mock inspections to ensure all requirements are met before launch. This comprehensive approach balances legal obligations with cultural preservation and user trust.

Conclusively, it is the spirit of building technology that honours tradition that illuminates the human-centred decisions made while building the Misala App. This project is more than just coding an app; it's about creating something that truly serves the communities who've nurtured this healing wisdom for generations. I am approaching this with humility, recognizing that I am not the expert here, but the traditional healers and elders are. My role is to build tools that protect their knowledge while making it accessible in ways they approve of. I am keeping things simple and transparent with no confusing legal jargon, but just clear conversations about what data is collected and who can see it. The healers will always remain in control of their remedies, with options to keep certain knowledge private or share it only with their community. I am using technology not to replace traditional practices, but to preserve them and help this wisdom reach those who need it, always with proper credit and respect. This is a living project that will grow and adapt as I continue listening to the communities I serve. Would the healers I am working with feel proud of what we're creating together? That's the question guiding every decision I make with this capstone project.

1.7 Significance and Justification

Upon successful implementation, this project will help preserve endangered indigenous knowledge by digitizing traditional medicinal plant information in both English and Luhya. The app will make this knowledge more accessible to younger generations and researchers, reducing reliance on oral transmission while promoting biodiversity conservation through increased awareness of medicinal plants.

The solution could improve rural healthcare access by enabling quick identification of medicinal plants for basic treatments, especially in areas with limited medical facilities. By incorporating crowdsourced verification, the app will grow more accurate over time, creating a sustainable system for documenting and protecting Kenya's herbal medicine heritage.

In the long term, this could inspire similar initiatives across Africa, fostering cross-cultural knowledge sharing while supporting global efforts to study and preserve traditional medicine. The project may also open doors for the ethical commercialization of herbal remedies, creating economic opportunities for local communities.

1.8 Research Budget

Table 1

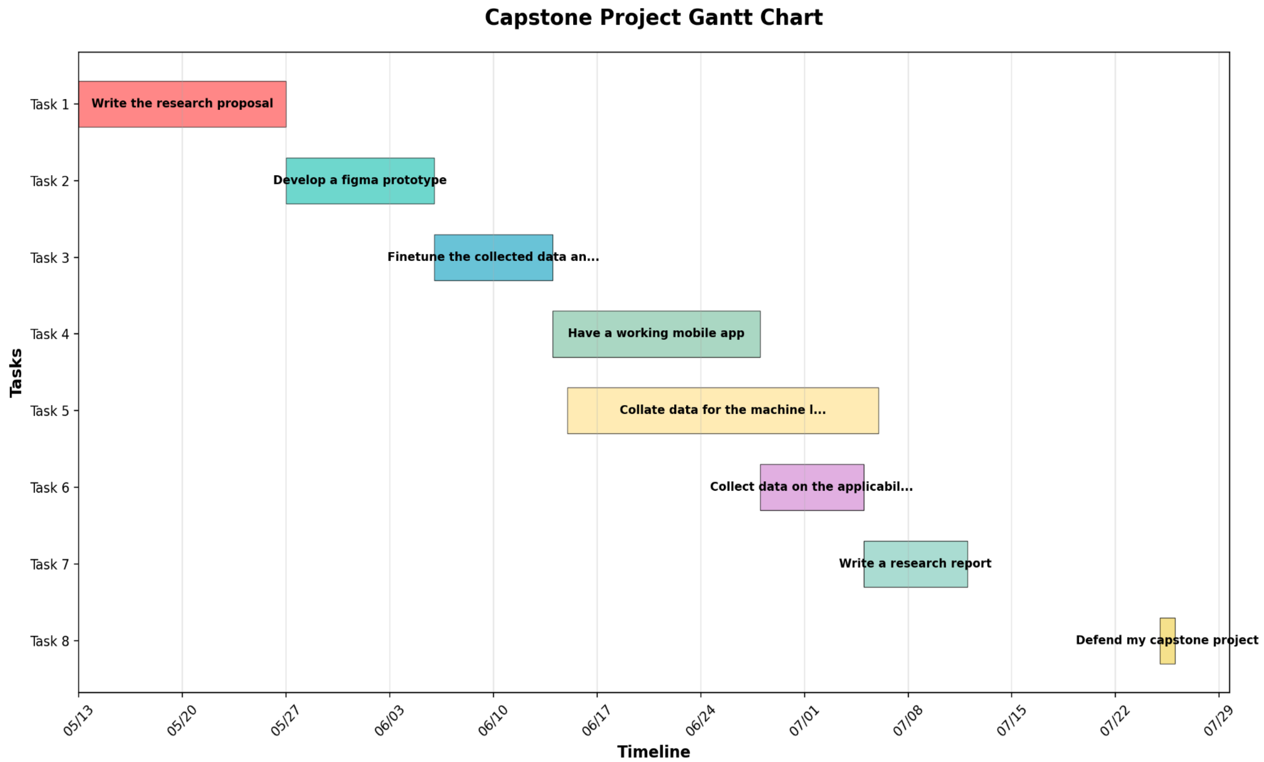
1	Component	Item	Specifications	Estimated_Cost_USD	Alternative
2	Development Setup	Personal Laptop/Desktop	Existing laptop with 8GB+ RAM, upgrade if needed	Free (existing) or $50 RAM upgrade	Use university computer lab if needed
3	Development Setup	External Monitor	Second-hand 24" monitor for dual setup	$50-100 (used)	Use single monitor setup
4	Development Setup	Development Tools	VS Code, Android Studio, Xcode (free)	Free	All development tools are free
5	Testing Devices	Personal Android Phone	Use existing Android device for testing	Free (existing)	Use university devices for testing
6	Testing Devices	Borrowed iOS Device	Borrow from friends/family for iOS testing	Free (borrowed)	Use online iOS simulators
7	Testing Devices	Android Emulator	Use Android Studio emulator for testing	Free	Physical device testing preferred
8	Cloud Services	Free Tier Cloud Hosting	Heroku/Vercel free tier for web hosting	Free	University hosting or GitHub Pages
9	Cloud Services	Free Database Service	PostgreSQL free tier (Supabase/Railway)	Free	SQLite for local development
10	Cloud Services	Free AI/ML Platform	Google Colab/Kaggle for AI model training	Free	Use university GPU resources
11	Storage & Backup	External Hard Drive	1TB external drive for backups	$50	Use cloud storage only
12	Storage & Backup	Cloud Storage	Google Drive/OneDrive free tier (15GB)	Free	Compress files to stay within limits
13	Field Research	Smartphone Camera	Use phone camera with macro lens attachment	$20 (lens attachment)	Use university equipment if available
14	Field Research	Notebook/Field Journal	Physical notebook for field observations	$5	Digital notes on phone/laptop
15					

GoogleDoc:https://docs.google.com/spreadsheets/d/1n6p462KHFG15XdE_CeYKv9k6yqh1mnnLzykEetLf8mw/edit?usp=sharing

1.9 Research Timeline

- Write the research proposal by 27/05/2025
- Develop a Figma prototype by 06/06/2025
- Collate data for the machine learning model by 06/07/2025
- Fine-tune the collected data and train the model by 06/14/2025
- Have a working mobile app by 06/28/2025
- Collect data on the applicability of the mobile app by 07/05/2025
- Write a research report by 07/12/2025
- Defend my capstone project by 07/26/2025

Figure 1



Detailed project plan: Misala App Capstone Project Plan.xlsx

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction
In the hunt for software-related literature, I specifically targeted research on machine learning models for plant identification, mobile app development for medicinal plants, and existing digital solutions for traditional medicine documentation. I used a systematic methodology, sampling peer-reviewed papers, conference proceedings, and technical reports from indexed platforms like ResearchGate, SpringerLink, PLOS, ScienceDirect, and BMJ Global Health, as well as app documentation from Google Play, App Store, and APKPure. After screening for relevance, I analyzed 12 key publications (e.g., Kumar et al. on LeafSnap, Pudaruth et al. on MedicPlant) to identify gaps, best practices, and technical approaches in ML-driven plant identification apps.

2.2 Historical Background of the Research Topic
African Traditional Medicine (ATM) has been practiced for millennia, with knowledge passed orally through generations. Colonialism disrupted these systems, marginalizing indigenous practices in favor of Western medicine. Post-independence, African nations began reclaiming ATM's value, leading to early academic studies (Kokwaro's Medicinal Plants of East Africa, 1976) and government initiatives like Kenya's Ministry of Health Traditional Medicine Unit (1990s).

The digital era introduced new challenges: rapid biodiversity loss and fading oral traditions, but also solutions. Early efforts included databases like PROTA (2000s) and mobile apps (Pl@ntNet, 2013). However, most tools lacked African medicinal plant coverage or local language support. Recent advances in machine learning demonstrate AI's potential to preserve ATM, though gaps remain in multilingual, context-aware systems for African communities. This project builds on this legacy by integrating Luhya language support and community-driven verification.

2.3 Overview of Existing Systems
Several digital tools have been developed to identify plants, including medicinal species, using machine learning and mobile technologies. However, most have limitations in serving African traditional medicine (ATM) needs. Below is a categorized summary:

2.3.1 General plant identification apps (Non-medicinal focus)
- *Pl@ntNet (2013) & iNaturalist (2008)*
  - Use crowdsourced image data and CNNs for plant ID.
  - Limitations: Few African medicinal species, no traditional use details, English-dominated.
- *LeafSnap (2012)*
  - Focuses on leaf-based ID using computer vision.
  - Limitations: Only covers North American/European flora, no medicinal info.

2.3.2 Medicinal plant-specific apps (Limited African coverage)
- *MedicPlant (2021, Mauritius)*
  - Offline deep learning app for medicinal plants.
  - Limitations: Only Mauritius-specific, minimal info display (no preparation methods).
- *Aayu App (2021, Sri Lanka)*
  - Ayurvedic plant ID with multilingual support (Sinhala/Tamil).

- Limitations: Struggles with diseased leaves, no African species.

2.3.3 African initiatives (Emerging but narrow)

- Plant Identifier: Herb, Bark (Ndonna, 2021, Cameroon)
- Includes medicinal uses, recipes, and a discussion forum.
- Limitations: Limited species (90% accuracy), no major local languages beyond English/French.

2.3.4 Key Gaps in Existing Systems

1. *Language*: Most apps exclude African languages.
2. *Geographic bias*: Few cover Kenya's medicinal plants comprehensively.
3. *Documentation depth*: Rarely include preparation methods or community verification.
4. *Technical robustness:* Models often fail with real-world variability.

2.4 Review of Related Work

2.4.1 Summary of Reviewed Literature

The reviewed literature reveals significant advancements in machine learning (ML) applications for plant identification, alongside critical gaps in addressing African Traditional Medicine (ATM) preservation. Studies such as Kumar et al. (2012) demonstrated the effectiveness of convolutional neural networks (CNNs) for leaf-based plant identification, while later works by Pudaruth et al. (2021) and Dassanayake et al. (2021) showed how deep learning models like ResNet and AlexNet could be adapted for medicinal plant recognition in apps like MedicPlant and Aayu. However, existing solutions remain limited in their applicability to ATM. General plant identification platforms like Pl@ntNet and iNaturalist lack comprehensive coverage of African medicinal species and local language support, as noted in WHO (2022) reports. African-specific initiatives, including Ndonna's Plant Identifier (2021), show promise but suffer from limited species coverage and insufficient localization. Scholarly research by Gakuya et al. (2020) and Makunga (2022) highlights the urgent need for digital preservation of ATM knowledge, which faces threats from biodiversity loss and fading oral traditions. Mutombo et al. (2023) further emphasize the importance of verified documentation to ensure safe usage of herbal remedies. Technical challenges persist, particularly in developing offline-capable, multi-organ identification systems with community verification mechanisms; features essential for rural African contexts but absent in current applications. This literature review underscores both the potential of ML for ATM preservation and the pressing need for solutions that integrate local languages, comprehensive medicinal plant databases, and community participation to effectively safeguard indigenous knowledge.

2.5 Strengths and Weaknesses of the Existing System(s)

Table 2

System	**Strengths**	**Weaknesses**
Pl@ntNet(general plant id)	- Uses advanced CNN models - Large crowdsourced database - Multi-platform (web/mobile)	- Few African medicinal species - No traditional use information - English only
iNaturalist(general biodiversity)	- Global community contributions - GPS-based species mapping - Open data for research	- Not focused on medicinal plants - Limited offline functionality - Requires internet for full features
LeafSnap(leaf based id)	- Pioneering computer vision approach - High accuracy for leaf morphology - Clean dataset (lab-controlled images)	- Only covers North American/European species - No medicinal use details - Discontinued updates
MedicPlant(Mauritius)	- Offline functionality - Deep learning (multi-organ ID) - Focused on medicinal species	- Limited to Mauritius flora - Minimal info display (no preparation methods) - No local African languages
Aayu App(Sri Lanka)	- Multilingual (English/Sinhala/Tamil) - Ayurvedic-specific content - Quiz feature for user engagement	- Poor performance on diseased leaves - No African species coverage - Small dataset
Plant Identifier: Herb, Bark (Cameroon)	- Includes medicinal uses/recipes - Forum for community discussion - 90% claimed accuracy	- Limited species (herb garden focus) - No major African languages beyond French - Unverified crowdsourced data

2.6 Proposed Solution

2.6.1 Features

Table 3

Main Feature	**Sub-Feature**	**Purpose**
Multi-language landing page	- English & Swahili language selection - Culturally relevant visuals - User testimonials	Improve accessibility for African users, especially Swahili speakers.
Smart Camera Scanner(**CORE**)	- Multi-organ ID (leaves, bark, flowers, roots) - Offline mode - "Real-world" mode (damaged/diseased plants) - History of identified plants	Accurate plant ID in rural areas, even with poor-quality samples.
Verified plant profile page	- Local names (Luhya, English, scientific) - Ailments treated - Step-by-step preparation guides	Provide reliable medicinal plant info with practical usage instructions.
Crowdsourced community wisdom	- User-submitted remedies (vetted by experts) - "Verify This" button for expert review	Preserve oral knowledge with verified accuracy.
Conservation hub	- Sustainable harvesting guides - Blogs on biodiversity protection	Promote ethical plant use and environmental awareness
Chatbot	- Rule-based chatbot for plant details	Quick access to additional plant info post-identification.

2.6.2 Uniqueness

Table 4

Feature	**My proposed solution**	**Others**
African language support	Luhya+English	Mostly English/French
Community verification	Crowdsourced+Expert vetted	unverified/none
Multi-organ offline ID	Leaves/barks/roots	Leaves only or online only

Conservation integration	Blogs	Rarely included
Cultural context	Prep videos+oral history	Clinical focus only
Dynamic Q&A chatbot	context aware	Static information only

2.7 General Comment and Conclusion

The literature review reveals that while existing machine learning-based plant identification systems demonstrate technical proficiency, they fail to adequately address the needs of African Traditional Medicine (ATM) preservation. Current solutions lack comprehensive coverage of African medicinal plants, local language support, detailed preparation methods, and community verification features; all critical for effective ATM documentation and utilization. The reviewed systems' strengths in image recognition and crowdsourcing provide valuable foundations, but their geographic biases, linguistic limitations, and technical constraints highlight the need for a more tailored solution. This project aims to bridge these gaps by developing an ML-powered application that specifically incorporates African medicinal knowledge, local languages like Luhya, and community participation to create a robust, culturally relevant tool for ATM preservation and dissemination.

CHAPTER THREE: SYSTEM ANALYSIS AND DESIGN

3.1 Introduction

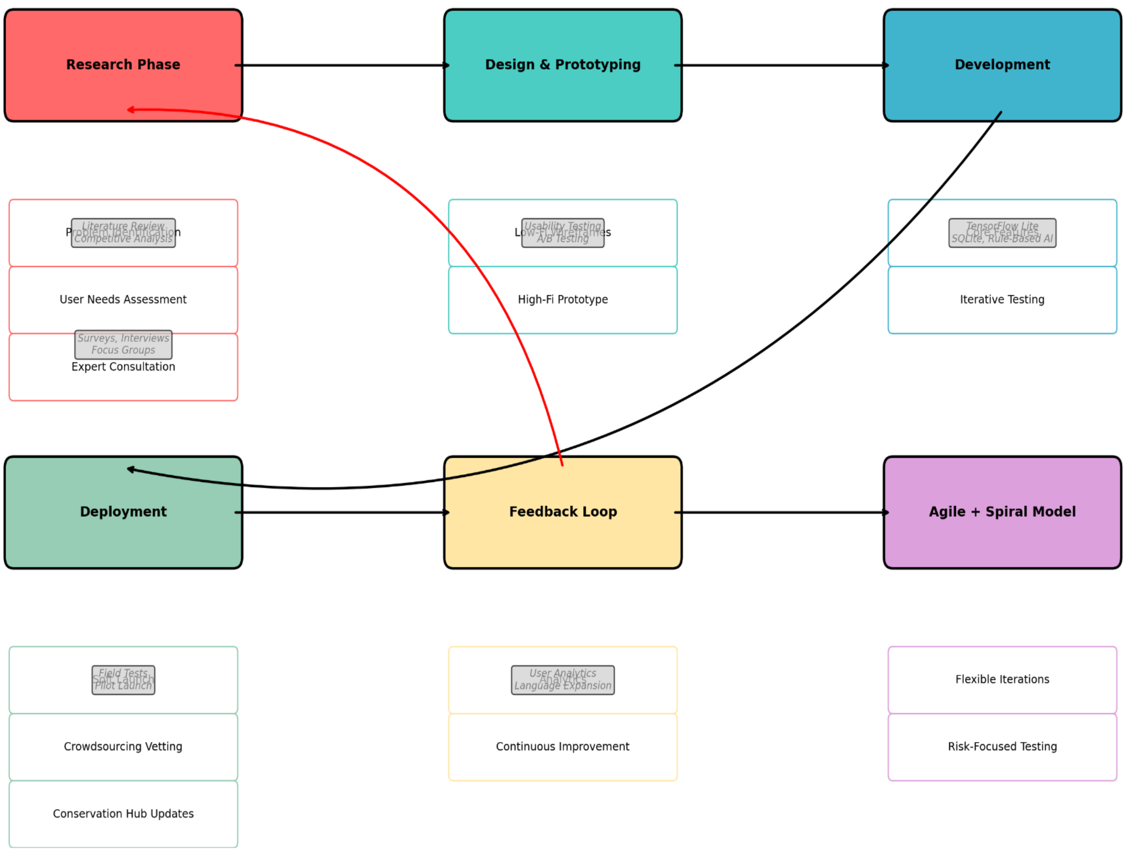
To design this mobile app, a user-centered design (UCD) approach will be employed, focusing on iterative testing and feedback from target users. Research methodologies include:

- Surveys and interviews to assess language preferences, pain points with existing apps, and feature priorities.
- Competitive analysis of similar apps to identify gaps in African language support, offline functionality, and medicinal plant data.
- Prototyping and usability testing (low-fidelity wireframes first, then high-fidelity mockups) to validate the multi-language UI, camera scanner efficiency, and chatbot interactions.
- Collaboration with ethnobotanists and local experts to verify plant data and crowdsourced content, ensuring accuracy.
- Offline-first development using tools like TensorFlow Lite for on-device plant identification and SQLite for local storage.
- Rule-based chatbot design using decision trees to provide instant, structured responses about plant uses. The app will prioritize accessibility, offline functionality, and community-driven knowledge preservation while balancing simplicity with robust features.

3.2 Research Design (including the development model used)

Figure 2

Research Design & Development Model Flowchart
Mobile App for African Medicinal Plants



3.3 Functional and Non-functional Requirements

Priority level (P0 = Critical, P1 = High, P2 = Medium, P3 = Low)

3.3.1 Functional Requirements

- P0 (Critical): Must-have for MVP
- P1 (High): Important for usability, but can follow post-launch
- P2 (Medium): Enhances UX but not urgent
- P3 (Low): Future improvements

Table 5

Feature	Functional Requirement	Priority
Multilingual landing page	Display language selection screen (English/Swahili) on first launch.	P0

	Store user language preference for future sessions.	P0
	Load culturally relevant visuals based on the selected language.	P1
	Show dynamic testimonials from app users (pulled from a database).	P2
Smart camera scanner	Capture images of plant organs (leaves, bark, flowers, roots).	P0
	Identify plant species using an offline ML model (TensorFlow Lite).	P0
	Toggle "Real-world mode" to adjust for damaged/diseased plants.	P1
	Save scan history locally (device storage).	P0
	Sync history to the cloud when online (optional).	P2
Verified plant profile	Display plant details: local names (Luhya, English, scientific).	P0
	Show ailments treated by the plant.	P0
	Provide step-by-step preparation methods (text)	P0
	Allow users to bookmark their favorite plants.	P1
Community wisdom section	Let users submit remedies (text + images).	P1
	Implement "Verify This" button for expert review (admin panel).	P1
	Display verified remedies with a badge.	P1
	Flag/report inappropriate submissions.	P2
Conservation Hub	Display guides on sustainable harvesting (PDF/text)	P1
	Show blogs/articles on biodiversity (fetch from CMS).	P2
Chatbot	Integrate a rule-based chatbot for plant FAQs (predefined Q&A pairs).	P1
	Link the chatbot to plant profiles for dynamic responses	P2

3.3.2 Non-functional Requirements

- P0 (Critical): Failure to meet these blocks app launch
- P1 (High): Important for trust/retention
- P2 (Medium): Scalability/future features
- P3 (Low): "Nice-to-have"

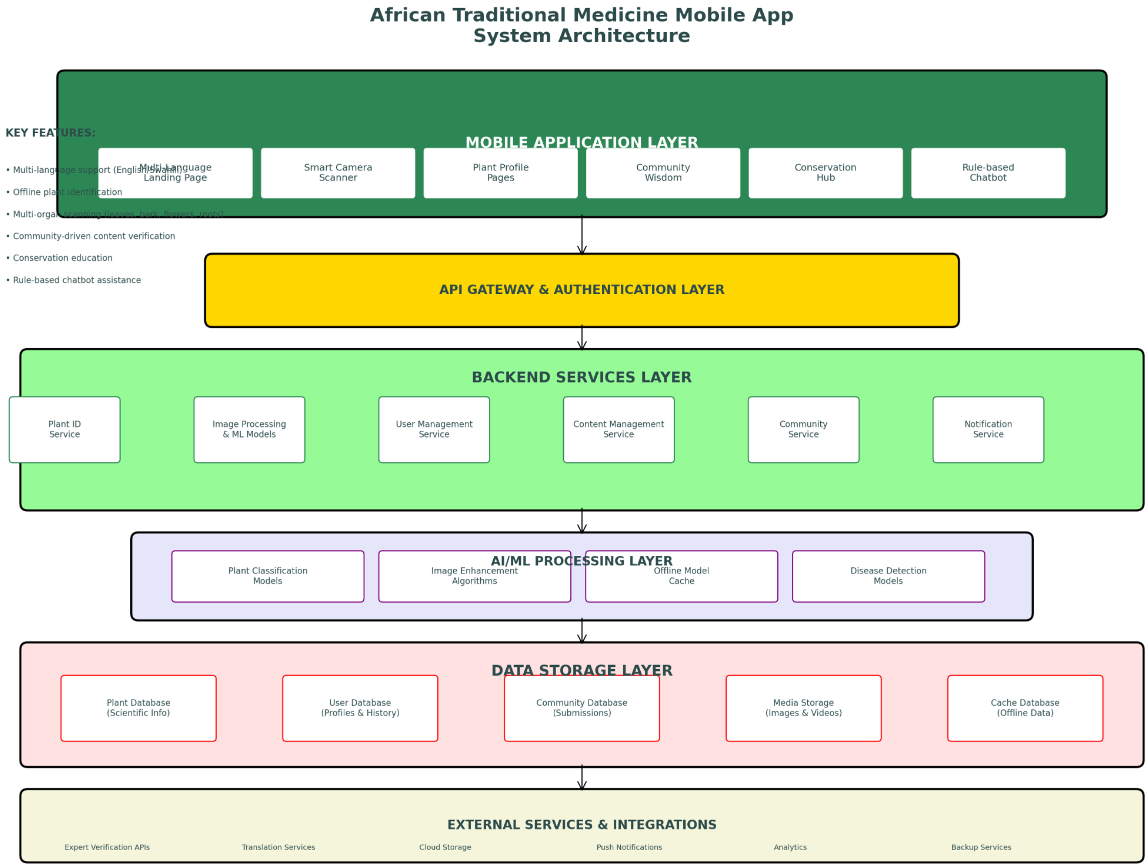
Table 6

Category	Requirement	Priority
Performance	The app should load the landing page in ≤2 seconds (online) and ≤1 second (offline).	P0
	Plant identification via scanner should process in ≤5 seconds (offline mode).	P0
	Chatbot responses should appear in ≤1 second.	P1
Usability	UI should be intuitive (≤3 taps to access core features like scanner).	P0
	Text/buttons must scale for low-literacy users (font size ≥16pt).	P1
	Support screen readers (TalkBack/VoiceOver) for visually impaired users.	P2
Reliability	Offline scanner must work with 85% accuracy (tested on medicinal plants in Luhya land).	P0
	The app should handle crashes gracefully (≤1 crash per 1,000 sessions).	P1
Scalability	The backend should support 10,000+ users without slowdowns.	P2
	The database should allow future addition of new languages (beyond Swahili).	P2
Security	User data (scan history, bookmarks) is encrypted locally (AES-256).	P1
	Secure API calls (HTTPS/TLS 1.2+) for cloud sync.	P1
Compatibility	Support Android 10+ and iOS 14+ (covering 90% of devices in target regions).	P0
	Optimize for low-RAM devices (≤2GB RAM).	P1
Maintainability	Codebase should allow modular updates (e.g., new plant databases).	P1
	Log errors for debugging (remote logging via Sentry/Firebase).	P2

Offline capability	Core features (scanner, history) must work 100% offline.	P0
	Sync data to the cloud when connectivity resumes.	P1
Legal/compliance	Comply with Kenya's Data Protection Act (if storing user data).	P1
	Disclaimers for medicinal advice ("Consult a doctor").	P1

3.4 System Architecture

Figure 3



Key Architecture Components:

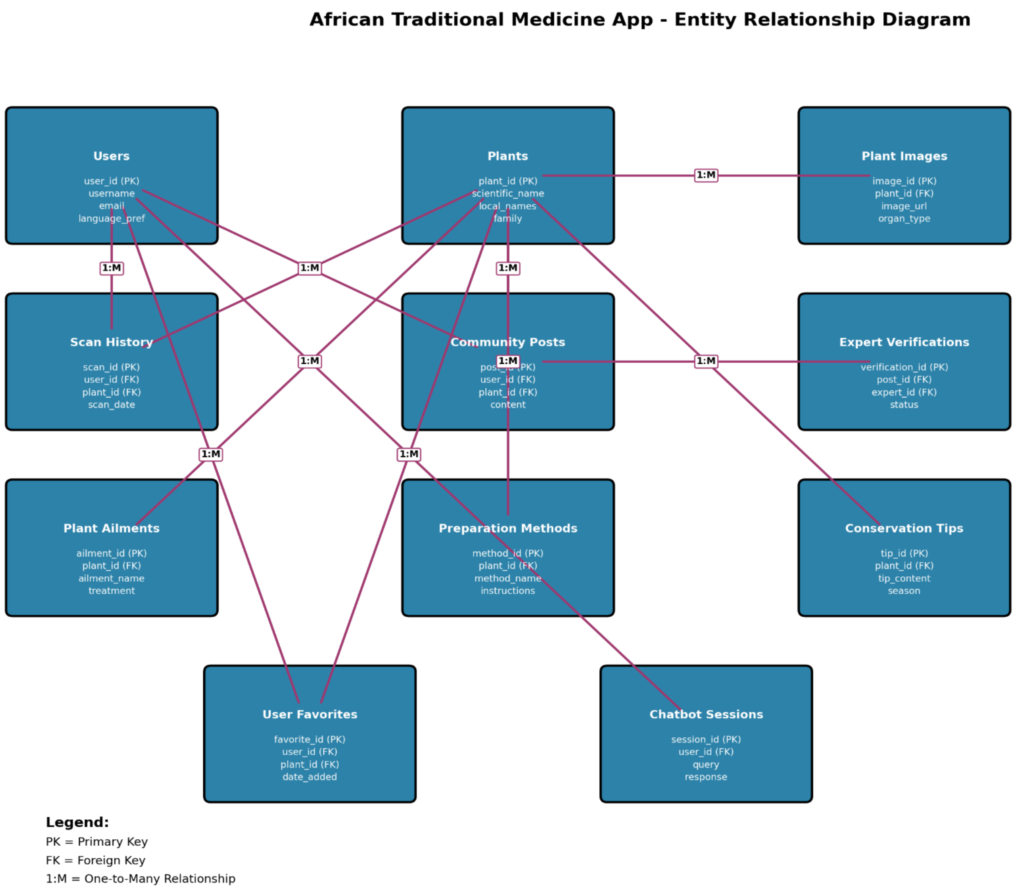
- Mobile Application Layer - User interface with 6 core features
- API Gateway - Authentication and request routing
- Backend Services - Microservices architecture
- AI/ML Layer - Plant identification and image processing
- Data Storage - Multiple databases for different data types
- External Services - Third-party integrations

The technical specification file is below:
https://docs.google.com/spreadsheets/d/14b5Xg8zNR0zQVsRnXomM6fcOvOPHyvxnXdb3Dboz8u8/edit?usp=sharing

3.5 UML Diagrams

3.5.1 ERD Diagram

Figure 4



The diagram above shows one-to-many relationships connecting users to their activities and plants to their associated information, enabling comprehensive plant identification, community knowledge sharing, and expert verification workflows.

11 entities are listed below:

Core Entities:

- Users - App users with language preferences
- Plants - Traditional medicinal plants with scientific and local names
- Plant_Images - Multiple images per plant

User Interactions:

- Scan_History - Records of plant identification scans
- Community_Posts - User-submitted remedies and knowledge
- User_Favorites - Saved plants for quick access
- Chatbot_Sessions - AI assistant conversations

Plant Information:

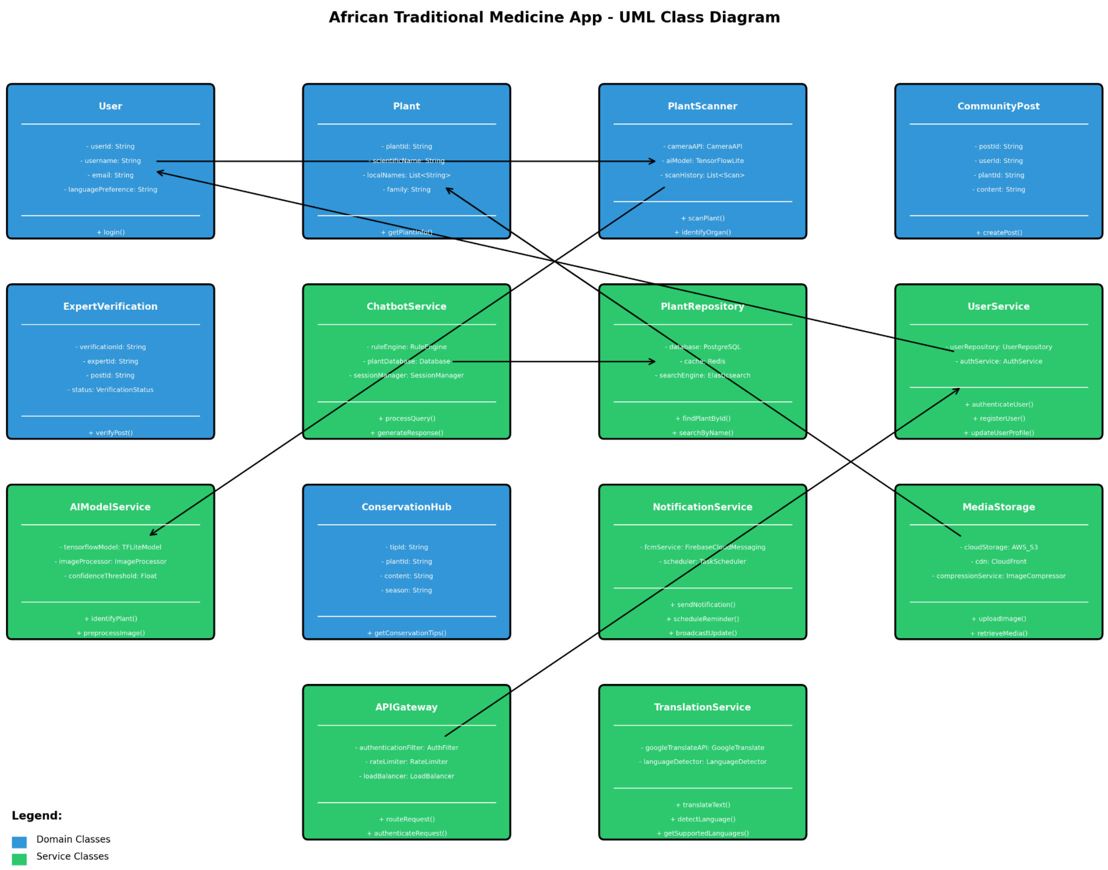
- Plant_Ailments - Conditions each plant treats
- Preparation Methods - How to prepare remedies
- Conservation_Tips - Sustainable harvesting guidance

Quality Control:

- Expert Verifications - Professional validation of community content

3.5.2 Class Diagram

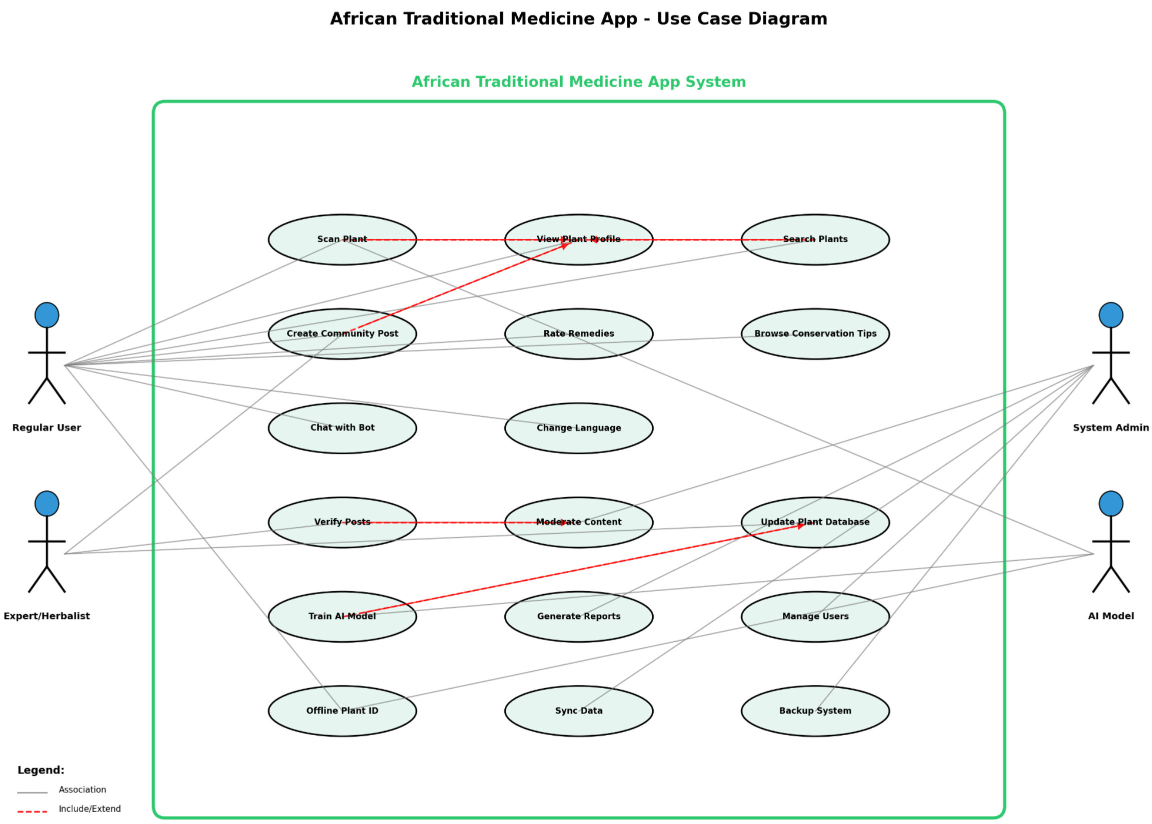
Figure 5



The UML class diagram shows the core architecture of the African Traditional Medicine app with 14 main classes organized into two categories.The relationships show how users interact with the scanner, which uses AI services to identify plants stored in the repository, while community posts get expert verification.

3.5.3 Use Case Diagram

Figure 6



The diagram demonstrates how different user types interact with various features while maintaining a clear separation of responsibilities and access levels. This use case diagram shows the interactions between four main actors and 17 use cases in the African Traditional Medicine app:

Actors:

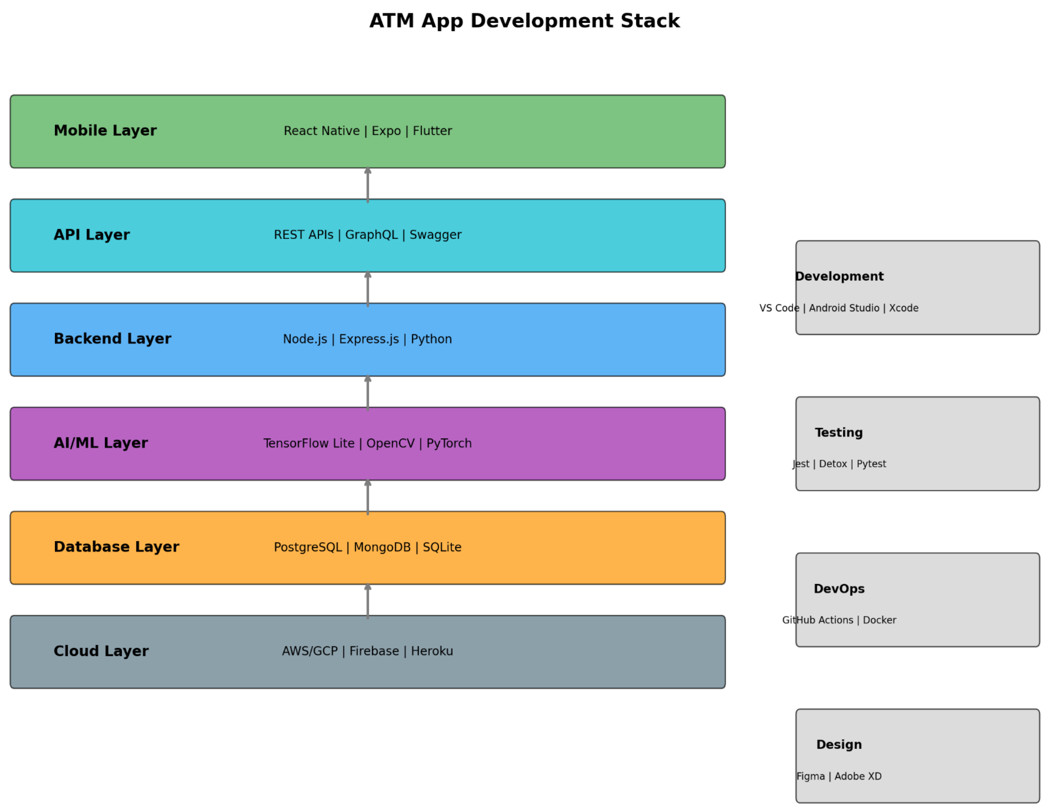
- Regular User: Scans plants, views profiles, searches, creates posts, rates remedies, browses conservation tips, uses chatbot, changes language, and accesses offline features
- Expert/Herbalist: Verifies community posts, creates expert content, and updates plant database
- System Admin: Moderates content, generates reports, manages users, handles backups, and data sync
- AI Model: Trains itself, performs offline plant identification, and supports scanning functionality

Key Relationships:

- Solid lines show direct associations between actors and use cases
- Dashed red lines indicate include/extend relationships where one use case depends on or extends another
- The system boundary encompasses all use cases within the app

3.6 Development Tools

Figure 7



3.7 Conclusion

This proposal outlines a transformative approach to preserving African Traditional Medicine (ATM) through an ML-powered mobile application. By addressing critical gaps in existing systems, such as limited African medicinal plant coverage, lack of local language support, and insufficient documentation, the project aims to safeguard indigenous knowledge for future generations. The app's integration of machine learning, multilingual functionality, and community-driven verification ensures accessibility and accuracy, particularly for rural and underserved populations.

The success of this project hinges on collaboration with local communities, herbalists, and ethnobotanists to validate plant data and ensure cultural relevance. Future enhancements could include features like video demonstrations of plant preparation, telemedicine scheduling with ATM professionals, and gamification to incentivize conservation efforts. By bridging traditional knowledge with modern technology, this initiative not only conserves biodiversity but also empowers communities with reliable, accessible healthcare resources. Ultimately, the project aspires to inspire similar innovations across Africa, fostering a sustainable ecosystem for ATM preservation and global recognition.

The next steps involve refining the ML model, conducting user testing, and iterating based on feedback to deliver a robust, user-friendly solution that meets the needs of its target audience. Through this endeavor, we hope to contribute meaningfully to the preservation of Africa's medicinal heritage while advancing healthcare equity and environmental stewardship.

Future work suggestions:

- Showing active ingredients and constituents of the medicinal plants.
- When a plant is identified, a video of its preparation and quantity is included, and also tells if the plant is endangered.
- A discussion forum for users to get more clarity from ATM specialists if needed(available to premium users).
- Telemedicine scheduling feature with ATM professionals(premium users).
- Gamification of the app, such that users can get rewards for contributing data(premium).
- More research into machine learning use cases in studying the molecular and structural composition of medicinal plants for use in viral diseases.
- Use of drone simulation through reinforcement learning technique to show how the model can be applied in identifying medicinal plants in large plantations like forests. Writing a research paper on this use case.
- Multilingual chatbot.

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