Title

CHUMA MUULIMI – AGRICULTURE SUSTAINABILITY KNOWLEDGE

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ABSTRACT

My final-year Bachelor of Science in Computer Science project led to the creation of **Chuma Muulimi** which functions as both a mobile and web-based application. This project investigates the potential of digital technology to resolve agricultural sector issues in Malawi. This application supports farmers with up-to-date agricultural information while fostering knowledge exchange and sustainable farming practices as well as enhancing market accessibility through mobile and web platforms. I conducted surveys and interviews with farmers, agricultural officers, and market vendors to guide the development process by understanding their real-world needs. The feedback from the farmers resulted in the creation of mobile and web application prototypes that included a knowledge hub, real-time weather updates, a discussion forum, and an online marketplace.

Before the app reached real-world deployment a limited number of test users already gave positive feedback. The application was expected to support farmers in making improved farming decisions and enable them to learn new techniques while simplifying the marketing and selling of their produce.

Chuma Muulimi demonstrates how merging mobile and web technologies can empower farmers while building stronger agricultural communities. This initiative proves that digital innovation and user-centered design methods generate effective solutions which will support upcoming development stages and real-world applications.

Keywords: Agricultural Technology, Knowledge Sharing, Mobile Application, Web Application, Sustainable Farming, Farmer Empowerment, Climate Resilience, Market Access

INTRODUCTION

Background

Agriculture is the backbone of Malawi’s economy, employing over 80% of the population and contributing significantly to national income. Despite its importance, the agricultural sector faces persistent challenges such as limited access to reliable farming information, unpredictable climate changes, poor market access, and a lack of modern farming techniques. These issues contribute to low productivity, food insecurity, and economic instability for many rural communities.

With the growing availability of both mobile technology and internet access, even in rural areas, there is a strong opportunity to bridge the information gap. Digital platforms can offer farmers real-time knowledge, connect them to wider markets, and promote sustainable farming practices. In light of these opportunities, there is a need to develop innovative and accessible digital tools that empower farmers and promote agricultural sustainability.

Context

This project, "**Chuma Muulimi**," was undertaken as part of my final-year Bachelor of Science in Computer Science degree. "**Chuma Muulimi**," or "Wealth in Farming," is a web and mobile application to meet the urgent needs of Malawian smallholder farmers. The application is centered on the application of digital technology to enhance information exchange, facilitate sustainable agriculture, enhance climate change resilience, and link farmers directly to markets using both mobile phones and web browsers.

The initiative is based on a desire to employ technology in transforming the face of agriculture in Malawi. By creating a centralized platform where farmers can access agricultural data, participate in forums, get customized advice, and carry out market operations, the initiative aims to contribute to sustainable rural development.

Although the application is not yet operational, the design and development took into consideration farmer and extension advisor feedback (user centric approach has been adopted in the design process) and market stakeholders' feedback during the research phase. The application thus serves real needs and provides a good basis for implementation in the real world.

Research/Project Objectives

The **Chuma Muulimi** project was conceived with an idea of using technology for the benefit of smallholder farmers in Malawi. Having studied Computer Science as a final-year student, my aim has been to find out how web and mobile applications can be employed to make a difference in the everyday life of farmers—particularly farmers in the rural areas, who often face challenges in accessing quality information and markets.

The key goals of the project are as follows:

To enable farmers by providing them with convenient access to timely, reliable, and localized Agri information through a digital platform with an accessibility feature on smartphones as well as the web.

To help improve climate resilience by providing real-time weather information and passing on good tips on sustainable agriculture practices suitable to local conditions.

To enhance market access by creating an online market platform through which farmers can purchase farm inputs needed and sell their products directly to consumers or middlemen, in a bid to minimize reliance on middlemen.

To understand how digital technology particularly when user-focused can solve everyday farming problems faced by most Malawian farmers.

Ultimately, this project is intended to show that competent digital tools have the potential to bridge the gap between farmers and information, resources, and markets necessary to thrive. My hope is that this work opens doors for ongoing development and creates opportunities for positive social and economic change in rural communities.

LITERATURE REVIEW

Introduction

The convergence of agriculture and mobile technology has commanded a lot of attention over the past few years, especially in developing nations where agriculture is a leading economic activity. Digital solutions can revolutionize the agriculture sector by enhancing productivity, sustainability, and market access for farmers. This review integrates current research on agricultural information systems, mobile agricultural applications, knowledge exchange in agriculture, and electronic solutions to market access and determines relevance to the **Chuma**

Muulimi project that incorporates mobile and web applications.

Agricultural Information Systems

Access to up-to-date and reliable agricultural information is essential for farmers in order to enable them to make more effective decisions. Research like Aker (2011) shows how mobile phones can fill the gap in information between producers and markets, increase bargaining power, and achieve producers improved prices. Mittal and Mehar (2016) also believe that mobile platforms for information services improve farm productivity and promote better adoption of best practice. Nevertheless, rural communities remain with low levels of literacy, poor digital capabilities, and linguistic constraints that are sure to interfere with agricultural information systems efficiency. **Chuma Muulimi** app fills the gap by localizing information and utilizing accessible interfaces in order to make it easy for farmers to use in Malawi.

Mobile Applications for Farming

Numerous mobile applications have been created worldwide to assist farmers. They include iCow in Kenya, which offers livestock tips through SMS, and mFarms in Ghana, which links farmers to suppliers and customers. Nakasone et al. (2014) established that mobile applications greatly enhance access to agricultural inputs, advisory services, and financial services. Although popular, most mobile applications are marred with poor localization and poor internet connectivity, particularly in rural areas. **Chuma Muulimi** app solves these problems by having web and mobile versions that reach out to users in regions with poor internet connectivity to make it more accessible and usable.

Knowledge Sharing and Community Engagement

Sharing of knowledge is key to sustainable agriculture, especially where there are climate change and market volatility effects. Davis et al. (2012) posit that participatory methods, where farmers exchange experiences and indigenous knowledge, result in improved adoption of innovations. Online platforms such as forums and discussion boards have been found to be viable means through which community interaction and common learning is boosted. They fill the spaces between expert knowledge and local practices. **Chuma Muulimi** incorporates these community engagement elements, wherein farmers can interact with others similar to them, learn from others' experiences, and solicit advice from experts, forming an interactive learning platform.

Climate-Smart Agriculture and Mobile Solutions

Climate-smart agriculture (CSA) targets enhanced agricultural productivity and climate change adaptation. Mobile technology is increasingly used in sharing information on the climate, including weather forecasts and adaptation. *Tall et al. (2014*) reported that farmers received accurate weather information through mobile messages and were able to modify planting calendars and minimize crop losses. Convergence of real-time climate information and weather data and climate-resilient technologies with web and mobile technologies, such as in **Chuma Muulimi**, assists farmers to make informed decisions, and this increases climate resilience.

Digital Marketplaces for Farmers

Web platforms are transforming farmers' marketing, enhancing market access, and minimizing post-harvest losses. Digital technology has been shown to link supply chains and boost farmers' incomes through internet-based markets such as Twiga Foods in Kenya and AgriDigital in Australia. *Ferris et al. (2014)* note that trust, transparency, and equitable pricing are the reasons why these platforms have succeeded. For Malawian farmers, reaching stable markets continues to be a paramount problem. The **Chuma Muulimi** program has an online platform that enables farmers to sell directly, making it possible for them to gain access to markets and encouraging fair price mechanisms.

Gaps in Existing Research

Despite widespread global research on mobile applications in agriculture, extremely little attention has been paid to the unique needs of Malawian farmers. Most applications are not localized into local languages, socio-economic realities, and cultural practices. Further, few have investigated the long-term sustainability and adoption of mobile solutions in developing environments. The **Chuma Muulimi** project aims to fill this gap by providing a solution that is specifically adapted to the specific needs of Malawian farmers, including localized content, community functionality, and market access tools that are intended to promote adoption and sustainability.

Conclusion

Literature reviewed underscores the transformative capacity of mobile technology for agriculture, particularly in areas of information transfer, climate resilience, and access to markets. However, such interventions will work if they are fashioned to respond to the local setting, and respond to the challenge of illiteracy, deprivation of internet access, and local acceptability. The **Chuma Muulimi** app draws inspiration from this study, incorporating localized content, community activity functionality, and market access elements into the app to address the requirements of Malawian farmers. Online platforms, if designed well, could empower farmers and support sustainable agriculture, alongside socio-economic development, the report indicates.

METHODOLOGY

Introduction

The next section presents an overview of the research and development methodology used for the **Chuma Muulimi** web-based and mobile application project. With my last-year Bachelor of Science in Computer Science project, more focus was laid on problem-solving based on applied research, prototype creation, and human-centered design. The method placed more emphasis on conceptualization, design, and prototype testing rather than real-world deployment.

Research Design

The project employed an Applied Research methodology whose goal was to address real-world problems of restricted access to agroinformation and market connections for small farmers in Malawi. There were two general phases that were followed:

- **Requirement Gathering:** Farmer needs identification through literature review, informal interviews, and observation.
- **Prototype Development:** Functional prototype design and development both for mobile and web platforms.

Data Collection Methods

1. **Literature Review**

Comprehensive secondary research was carried out using academic journals, NGO reports, government reports, and actual case studies on:

- Agricultural challenges in Malawi
- Successful mobile and web-based agricultural solutions globally
- Climate resilience interventions and digital market systems

2. **Informal Interviews**

Unstructured interviews were held with:

- Two smallholder farmers
- One agricultural extension officer

This combination allowed for scalable, accessible, and user-friendly designs across both mobile and web environments.

System Development Methods

1. **User-Centered Design (UCD)**

The methodology employed a User-Centered Design approach:

- Constructed personas of typical Malawian farmers with differing digital literacy levels.
- One representative of a local agricultural market

These interviews gave insights into the actual needs of the target users and assisted in adjusting the platform features.

3. **Observational Research**

Rural internet and mobile usage observation, network quality, and digital literacy of farmers among other factors drove design decisions to keep things basic and offline-enabled.

Tools and Technologies Used

Tool/Technology	**Purpose**
Android Studio	Mobile app development (Java/Kotlin)
Firebase (Realtime Database, Authentication, Hosting)	Backend services for both mobile and web apps
Figma	UI/UX design prototypes for the platforms
Google Cloud Messaging (GCM)	Push notifications for weather and updates
Github	Version control and collaborative development
React.js	Web application front-end development
Photoshop/ Canva	Visual materials and branding design
Chichewa Language Resoures	Localization for English and Chichewa users

- Prioritized plain interfaces, navigation clarity, and bilingual functionality (English and Chichewa).
- Essel illustrates informal user testing to ensure usability of the web and mobile platforms.

2. Agile Development

An Agile process controlled the project:

- Delivery was made in short, iterative sprints.
- Preliminary sprints targeted foundational modules: Knowledge Hub, Marketplace, and Discussion Forum.
- Flexibility enabled tweaking the design based on constant feedback.

System Design and Prototyping

Process involved:

- Building low-fidelity and high-fidelity wireframes using Figma.
- Developing a shared backend infrastructure using Firebase, accessible via web and mobile clients.
- Development of functional prototypes emphasizing important features such as:
  - Agricultural Knowledge Sharing
  - Live Weather Updates
  - Digital Marketplace
  - Farmer Community Forum

Testing was done with a couple of colleagues acting as farmers and market vendors.

Ethical Considerations

Though no formal interviews were conducted, the following ethical standards were adhered to:

- Transparency in reporting academic intent of the project
- Voluntary feedback and interviews
- Privacy of participants (no collection of sensitive information)
- Security and privacy concerns in the future were integrated into system designs.

Limitations

- No large-scale deployment or live testing with actual farmers.
- Low group diversity being tested.
- Internet consistency and mobile/web platform compatibility were simulated only. These constraints are noted and look towards improvement in future deployments.

Conclusion

The **Chuma Muulimi** project integrated literature review research, non-formal stakeholder feedback, user-centered design, and agile development methodologies to deliver web and mobile application prototypes. While yet to be deployed in the real world, the project presents a viable platform for future real-world deployment to enable Malawian farmers through digital empowerment.

RESULTS

Introduction

The **Chuma Muulimi** mobile application prototype was successfully deployed to the web

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and mobile, validating the potential of digital technologies for empowering Malawian farmers by providing them with agricultural information as well as market access. In this section, the key findings from the design, development, and internal testing phases of the project are captured.

Prototype Features Developed

The project produced working prototypes for:

- **Android mobile application** (primary access for farmers with smartphones).
- **Responsive web application** (for broader access via any internet-enabled device). The following core features were developed for both platforms:

Both platforms (mobile and web) prioritized:

- **User-Friendliness**: Simple layouts, clear navigation, and intuitive icons.
- **Language Localization**: Full support for both English and Chichewa.
- **Visual Content**: Emphasis on pictures and simple diagrams to support users with limited literacy.
- **Responsiveness**: Web version designed to adjust to different screen sizes, ensuring usability on phones, tablets, and laptops.

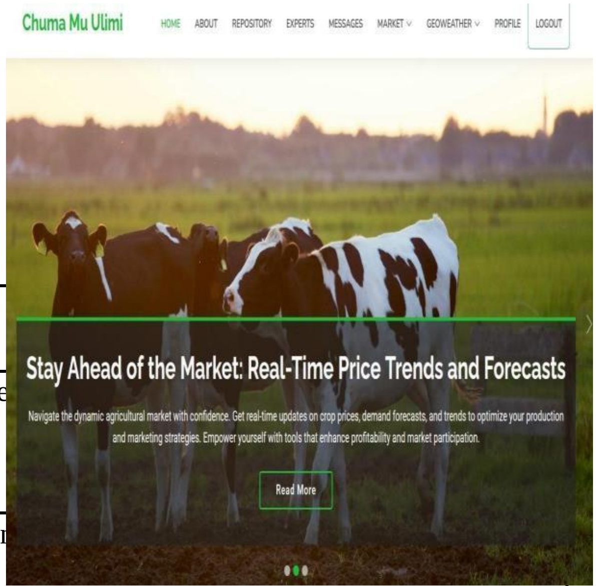

Figure: Home Page

Feature/Module	Description
Knowledge Hub	Repository of farming guides, pe… and climate tips.
Farmer Forum	Discussion board where users ca… peer advice.
Marketplace	Platform to post and view agricultural products for sale or purchase.
Weather Updates	Push and browser notifications for upcoming weather conditions.

Usability Testing Outcomes Participants

Feature/Module	Description
Language Support	Interfaces available in both English and Chichewa for better user accessibility.

Interface Design Outcomes

 DOI:10.5281/zenodo.15449805

A group of **5 simulated users** (students role-playing as farmers) interacted with both the mobile app and the web application.

Tester Role	Mobile App Feedback	Web App Feedback
Farmer 1	Easy to navigate, loved language option.	Web version slightly slow to load on mobile browser.
Farmer 2	Marketplace easy to use.	Appreciated bigger screen for browsing products.
Farmer 3	Wanted more images per product listing.	Requested a search/filter feature.
Farmer 4	Found offline caching very helpful.	Found design clean but suggested larger buttons.
Farmer 5	Suggested audio guides for illiterate users.	Noted that web version was data heavy.

Observations

Both versions were generally **well received**.

- Mobile app performance was faster, especially for users with weaker internet connections.
- Web app offered better browsing experience on larger devices but needed optimization for low-bandwidth usage.

Table 2: Usability Feedback Summary

Criteria	Mobile App Rating (out of 5)	Web App Rating (out of 5)
Ease of Navigation	4.2	4.0
Visual Appeal	4.0	4.2
Language Accessibility	4.6	4.6

Criteria	Mobile App Rating (out of 5)	Web App Rating (out of 5)
Content Relevance	4.5	4.5
Speed and Performance	4.0	3.5

Technical Results Backend Functionality

- **Firebase Realtime Database** was successfully integrated across both web and mobile.
- **Authentication** allowed users to create accounts and log in securely on both platforms.
- **Real-time content updates** worked seamlessly between web and mobile (e.g., when a new marketplace listing was added via mobile, it appeared instantly on the web).

Cross-Platform Testing

- Mobile App: Tested on Android devices with Android 8.0 and above.
- Web App: Tested on Chrome, Firefox, and Edge browsers on smartphones, tablets, and laptops.
- Responsive design worked well across screen sizes, although slower loading was observed on older smartphones.

Challenges Encountered

- **Data Consumption**: The web app initially consumed more data than ideal for rural users with limited internet packages.
- **Device Performance**: Lower-end smartphones struggled slightly with

the web version compared to the mobile app.
- **Browser Compatibility**: Minor styling inconsistencies were observed between Chrome and Firefox on mobile browsers.

Summary of Findings

The development and evaluation of the **Chuma Muulimi** prototypes show that:

- Dual-platform access (mobile and web) increases inclusivity for farmers with different types of devices.
- Simplicity, visual design, and offline access are key for rural user engagement.
- Lightweight mobile apps perform better in low-connectivity environments compared to web browsers.
- Further improvements like content compression, audio support, and advanced marketplace filters could enhance user experience.

Although full real-world deployment was outside the project's scope, the prototypes provide a strong foundation for future testing and scaling.

System Implementation

Introduction

The **Chuma Muulimi** project was implemented as a working prototype for both Android mobile and web platforms. The implementation phase focused on translating the design into functional systems while ensuring that core features worked reliably across devices and internet conditions.

Development Environment

Aspect	**Details**
Mobile App IDE	Android Studio (Java/Kotlin)
Web App IDE	Visual Studio Code (HTML, CSS, Java
Backend Services	Firebase Realtime Database, Firebase A
Cloud Messaging	Google Cloud Messaging (Push Notific
UI/UX Design Tool	Figma
Version Control	GitHub

Mobile Application Implementation

The mobile application was designed natively for Android to maximize performance and offline capabilities.

- **Splash Screen**: Displays project logo and slogan.
- **Authentication**: New users could sign up, and existing users could log in securely.
- **Home Dashboard**: Quick access to Knowledge Hub, Marketplace, and Community Forum.
- **Offline Caching**: Certain content (e.g., guides) was cached for offline access.
- **Notifications**: Weather updates and farming tips were pushed to users based on their region.

Web Application Implementation

The web application was designed using responsive web technologies to ensure access via smartphones, tablets, and desktops.

- **Responsive Layout**: Bootstrap

framework was used to create a mobile-first design.

- **Browser Notifications**: Weather alerts appeared as desktop or mobile browser notifications.
- **Real-Time Updates**: Marketplace and forum posts updated instantly without needing page refresh.
- **Language Toggle**: Users could switch between English and Chichewa easily.

Key Implementation Challenges

Challenge	Resolution Strategy
Handling poor network connections	Enabled local caching for critical content.
Managing real-time updates	Integrated Firebase database listeners.
Balancing speed vs. design on low-end devices	Reduced image sizes, compressed assets.
Ensuring consistent experience across devices	Rigorous cross-browser and device testing.

DISCUSSION

The **Chuma Muulimi** project demonstrated that digital platforms (both web and mobile) can offer sustainable solutions to agricultural knowledge gaps in Malawi. Through internal testing, the prototype revealed several critical insights:

- **Mobile preference**: Users preferred the mobile app due to better performance in low- internet conditions.
- **Language accessibility**: Supporting both English and Chichewa made the app more inclusive and user-friendly.
- **Marketplaces are highly valued**: Testers strongly appreciated the ability to view and post crop listings easily.
- **Offline access is crucial**: Internet instability in rural areas requires that essential content be available offline.

However, challenges such as data consumption, device compatibility, and digital literacy need to be addressed in any future scaling or deployment.

CONCLUSION

The **Chuma Muulimi** application successfully met its primary objectives:

- Providing a centralized platform for farmers to access agricultural knowledge.
- Facilitating community interaction through a forum.
- Creating a basic digital marketplace for farm products.
- Offering real-time weather alerts to improve farming decisions.

Even though the project is still in the prototype phase, it provides a good basis for future growth and testing in the real world. Some other ideas are huge user testing with actual farmers, inclusion of audio support for users with low literacy, improvement of offline functionality, and web app optimization for low-bandwidth networks.

The project also demonstrates that technology can be an enabling factor for rural communities and assist in sustaining agriculture and socio-economic development if designed and oriented to meet local needs.

REFERENCES

1. Food and Agriculture Organization of the United Nations (FAO). (2017). *The future of food and agriculture: Trends and challenges.* Rome: FAO. [Available at: https://www.fao.org/3/i6583e/i6583e.pdf]
2. GSMA. (2020). *The mobile economy sub-Saharan Africa 2020.* GSMA Intelligence. [Available at: https://www.gsma.com/mobileeconomy/sub-saharan-africa/]
3. International Fund for Agricultural Development (IFAD). (2016). *Rural development report 2016: Fostering inclusive rural transformation.* Rome: IFAD. [Available at: https://www.ifad.org/en/web/knowledge/publication/asset/39247861]
4. CTA Technical Centre for Agricultural and Rural Cooperation. (2019). *The Digitalisation of African Agriculture Report 2018–2019.* Wageningen: CTA. [Available at: https://www.cta.int/en/digitalisation/all/digitalisation-of-african-agriculture-report-2018-2019-sid0d1e44e10-3f1a-4b7e-9b8b-097db974e1df]
5. ITC Limited. (2021). *e-Choupal: Empowering Indian farmers through web portal*. Retrieved April 27, 2025, from https://echoupal.itcportal.com
6. Twiga Foods. (2021). *Twiga Foods: An e-commerce platform connecting farmers and vendors in Kenya*. Retrieved April 27, 2025, from https://twiga.com
7. AgriDigital. (2020). *AgriDigital: Blockchain-enabled web platform for agribusiness supply chains*. Retrieved April 27, 2025, from https://www.agridigital.io
8. Aker, J. C. (2011). Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics, 42*(6), 631–647. https://doi.org/10.1111/j.1574-0862.2011.00545.x
9. Davis, K., Ekboir, J., Mekasha, W., Ochieng, C., Spielman, D. J., & Zerfu, E. (2012). Strengthening agricultural education and training in sub-Saharan Africa from an innovation systems perspective: Case studies of Ethiopia and Mozambique. *The Journal of Agricultural Education and Extension, 18*(3), 231–245. https://doi.org/10.1080/1389224X.2012.707063
10. Ferris, S., Engoru, P., & Kaganzi, E. (2014). Making market information services work better for the poor in Uganda. *Development in Practice, 18*(4–5), 525–534. https://doi.org/10.1080/09614520802181005
11. Mittal, S., & Mehar, M. (2016). Socio-economic factors affecting adoption of modern information and communication technology by farmers in India: Analysis using multivariate probit model. *The Journal of Agricultural Education and Extension, 22*(2), 199–212. https://doi.org/10.1080/1389224X.2015.1026365
12. Nakasone, E., Torero, M., & Minten, B. (2014). The power of information: The ICT revolution in agricultural development. *Annual Review of Resource Economics, 6*(1), 533–550.

https://doi.org/10.1146/annurev-resource-100913-012714

13. Tall, A., Hansen, J. W., Jay, A., Campbell, B. M., Kinyangi, J., & Aggarwal, P. K. (2014). Scaling up climate services for farmers: Mission possible. *CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) Report No. 13*. https://cgspace.cgiar.org/handle/10568/53101