International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 11 | Nov - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

GramSetu: Agricultural Support System for Rural India

Author: **Mukund Kumar Singh, Prathamesh Lohar, Nandini Gujarathi, C Sreerag.**
MCA Students, P.E.S Modern College of Engineering
Project Guide: **Mrs. Ashwini R Garkhedkar**
Assistant Professor, P.E.S Modern College of Engineering

Abstract

Agriculture remains the backbone of India's economy, with a majority of the population depending on it for livelihood. However, rural farmers often lack access to real-time agricultural information, modern technology, and market intelligence. This digital divide significantly limits productivity, sustainability, and economic growth in the sector. This paper proposes "GramSetu," a comprehensive mobile application designed to bridge this gap. The system leverages artificial intelligence, cloud technologies, and robust multilingual support to provide personalized farming advice, real-time weather forecasts, current market trends, and consolidated government scheme information. The primary goal is to empower Indian farmers by integrating cutting-edge technology with grassroots needs, promoting sustainable practices through a unified, AI-driven, and user-friendly digital platform.

Keywords— agriculture, mobile application, artificial intelligence, multilingual support, decision support, India

I. INTRODUCTION

OVER HALF of India's population depends on agriculture for their livelihood, making it the backbone of the nation's economy [1]. Despite its importance, the sector is hindered by a persistent digital divide; farmers in rural areas often lack access to modern technology, real-time data, and crucial market intelligence [2]. This gap is exacerbated by systemic barriers, including minimal technological adoption, limited access to expert advice [3], and language diversity that makes most English-centric platforms inaccessible [4]. Furthermore, low digital literacy and a lack of awareness mean that beneficial government schemes often go underutilized [5].

To address these challenges, this paper introduces GramSetu (meaning "Bridge to Villages"), a comprehensive mobile application developed to connect traditional farming practices with the digital revolution [6]. The system acts as a unified digital platform, leveraging artificial intelligence (AI) and cloud technologies to provide farmers with personalized advice, weather forecasts, market data, and scheme information in their own local language [7]. The application is designed with user-centric principles, ensuring accessibility for users with varying levels of digital literacy and connectivity constraints.

The key objectives of this work are [8]:

1. To develop an inclusive, multilingual platform that supports major Indian languages [9].
2. To integrate AI-powered decision support for intelligent crop recommendations based on regional conditions [10].
3. To provide real-time market prices and weather updates via external Application Programming Interfaces (APIs) [11].
4. To centralize information on government agricultural schemes and subsidies [12].
5. To design a user-friendly interface with voice input optimized for low-literacy users [13].
6. To ensure offline accessibility for users with limited connectivity [14].

This paper is organized as follows: Section II presents the literature survey examining existing work in mobile agricultural technology and AI applications. Section III describes the proposed system architecture and methodology. Section IV details the implementation and testing procedures. Section V discusses the results and implications. Finally, Section VI concludes the paper and outlines future research directions.

II. LITERATURE SURVEY

The development of GramSetu is informed by extensive research in mobile agricultural technology, artificial intelligence applications in farming, and multilingual interface design. This section reviews key studies that have shaped the conceptualization and design of the proposed system.

A. Mobile Applications in Agriculture

S. Kumar et al. (2020) provided a comprehensive systematic review of mobile applications in agriculture [15]. Their analysis revealed that existing applications often focus on niche areas, such as weather monitoring or crop management alone [16], and most lack a unified ecosystem that integrates market data, weather information, and government schemes

[17]. The study highlighted significant challenges in user adoption in rural regions, primarily attributed to low literacy rates and language constraints [18]. These findings underscore the need for holistic platforms that address multiple farmer needs simultaneously while ensuring linguistic accessibility.

B. Artificial Intelligence in Agricultural Advisory Systems

M. Patel et al. (2023) conducted an extensive review of AI applications in agriculture, noting significant benefits for predictive analysis, pest detection, and personalized advisory systems [19]. Their research emphasized that Natural Language Processing (NLP) enables farmers to interact with systems in their native languages [20], thereby reducing barriers to technology adoption. Machine learning models demonstrated strong potential for context-aware crop recommendations based on soil conditions, climate data, and historical yield patterns [21]. GramSetu builds upon these findings by integrating AI-based conversational interfaces and personalized advisories tailored to localized agricultural conditions [22].

C. Multilingual Information Systems for Rural Technology Adoption

R. Singh et al. (2024) emphasized that multilingualism is critical for inclusive technology adoption in rural areas of India [23]. Their study noted the complexity of accurately translating agricultural terminology across diverse local dialects and advocated for context-aware translation models combined with visual UI elements to ensure comprehension [24]. The research demonstrated that voice-based interfaces significantly improve usability among low-literacy populations. GramSetu employs these principles by utilizing Google Gemini's advanced NLP capabilities for context-based translation and implementing icon-based navigation with voice input/output functionality [25].

While existing research has made significant contributions to agricultural technology, a critical gap remains: the absence of comprehensive, AI-driven platforms that integrate multiple information sources (market, weather, schemes) with multilingual support and offline functionality. GramSetu addresses this gap by providing a unified solution specifically designed for the Indian agricultural context.

III. PROPOSED SYSTEM

A. Problem Definition

The project addresses the digitally underserved status of Indian farmers, which stems from several interrelated challenges [26]:

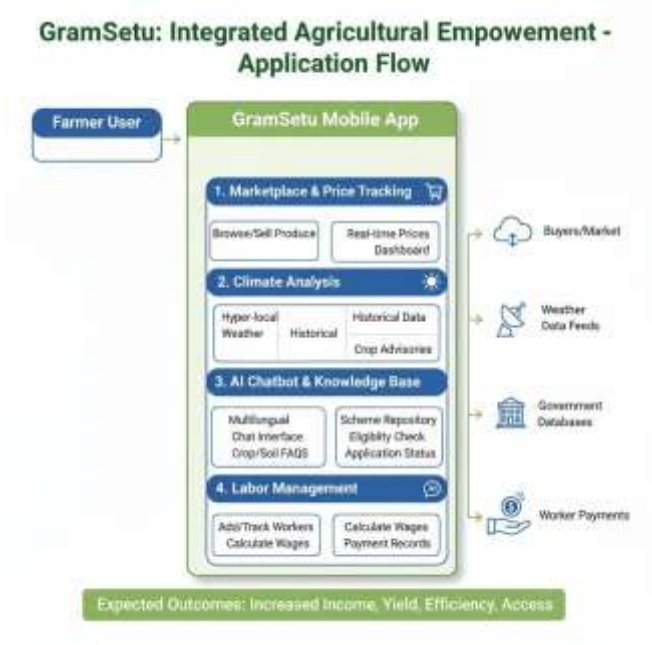
1. Fragmented Information: Agricultural information is scattered across multiple sources with no centralized platform.
2. Lack of Localized Platforms: Most existing solutions are not designed for Indian languages and regional farming practices.
3. Absence of Real-Time Insights: Farmers lack access to current market prices, weather forecasts, and actionable advice.
4. Limited Awareness: Government schemes and subsidies remain underutilized due to poor information dissemination.

The formal problem statement is defined as follows: To design and develop a multilingual, AI-powered, mobile-based agricultural support system that bridges the gap between rural farmers and digital resources by providing real-time information, personalized guidance, and an intuitive user experience [27].

B. System Architecture

The GramSetu architecture follows a modular client-server model designed for scalability and maintainability [28]. The system comprises five core layers:

1. Mobile Client Layer: A React Native application that handles the user interface, local data caching, and offline storage capabilities [29].
2. Application Server Layer: Utilizes Firebase Cloud Functions to process user requests, coordinate between services, and manage business logic [30].
3. AI Processing Layer: Integrates the Google Gemini API for contextual understanding, natural language query processing, and generating personalized farming recommendations [31].
4. Database Layer: Employs Cloud Firestore for structured, scalable, and real-time data management with automatic synchronization [32].
5. External Integration Layer: Connects to third-party APIs including weather services (OpenWeather API), market price databases (AgriMarket API), and government scheme repositories through RESTful services [33].



This modular architecture ensures separation of concerns, facilitates independent scaling of components, and enables seamless integration of additional features and data sources in future iterations.

C. System Requirements

The system design is guided by comprehensive functional and non-functional requirements that ensure usability, performance, and security [34].

1) Functional Requirements:

User Authentication: Secure login via phone number, email, or social media accounts with multi-factor authentication support.

Profile Management: Stores user details including geographic region, preferred language, crop types, and farm size.

Multilingual Interface: Comprehensive support for major Indian languages including Hindi, Bengali, Telugu, Tamil, Marathi, and regional dialects.

AI Chatbot: An intelligent conversational assistant capable of answering farming queries, providing crop recommendations, and offering pest management advice.

Weather Monitoring: Real-time weather forecasting with severe weather alerts and historical climate data analysis.

Market Price Tracking: Current commodity prices for major crops across different mandis (markets) with trend analysis.

Government Scheme Information: Centralized access to agricultural subsidies, loans, insurance schemes, and eligibility criteria.

Offline Access: Local caching of essential data enabling core functionality without internet connectivity.

2) Non-Functional Requirements:

Performance: Application launch time under 3 seconds with API response time under 2 seconds, optimized for low-end Android devices with limited RAM (2GB) [35]. Security: End-to-end AES-256 data encryption, secure JWT-based authentication, and OAuth 2.0 for API access control [36]. Usability: Intuitive, icon-based navigation with voice input/output functionality designed for users with low digital literacy [37]. Reliability: 99.9% system uptime via Firebase hosting infrastructure, automated daily backups, and comprehensive error logging with crash analytics [38].

D. Technology Stack

The platform is built using a modern, scalable technology stack that balances performance, developer productivity, and cross-platform compatibility [39].

1) Core Technologies:

Frontend Framework: React Native with Expo SDK for cross-platform mobile development (iOS and Android) [40].

Backend Infrastructure: Firebase suite including Authentication, Cloud Firestore database, and Cloud Functions for serverless computing [41].

AI Engine: Google Gemini API for natural language understanding, contextual responses, and intelligent recommendations [42].

Localization: i18next internationalization framework with dynamic language switching [43].

Offline Storage: AsyncStorage for persistent local data caching and offline-first architecture [44].

External APIs: OpenWeather API for meteorological data and AgriMarket API for commodity pricing [45].

Type Safety: TypeScript for static type checking and improved code maintainability [46].

2) Development Tools:

The development environment comprises Visual Studio Code as the primary Integrated Development Environment (IDE) [48], Android Studio and Xcode for device emulation and testing [49], Git version control with GitHub for collaborative development [50], Postman for API endpoint testing and debugging [51], and ESLint with Prettier for code quality enforcement and consistent formatting [52].

E. Methodology

The development of *GramSetu* followed a structured and iterative approach:

1. **RequirementAnalysis:**
User needs were gathered by reviewing existing

agricultural apps and understanding farmers' challenges such as language barriers, lack of real-time data, and low digital literacy.

2. **System Design:**
A modular client–server architecture was designed using React Native for the mobile app, Firebase for backend services, and external APIs for weather, market prices, and scheme information.

3. **Data Integration:**
Weather data (OpenWeather API), mandi prices (AgriMarket API), and government scheme details were collected, cleaned, and integrated into the system.

4. **AI Integration:**
The Google Gemini API was used to build a multilingual chatbot. Prompt engineering and context handling ensured accurate farming advice in local languages.

5. **Development Process:**
An Agile model was followed. Features were built in small sprints—authentication, weather module, market prices, AI chatbot, offline support, and UI refinement.

6. **Testing:**
Unit tests, integration tests, and usability testing were performed. A pilot trial with 50 farmers helped validate ease of use, accuracy, and performance on low-end devices.

IV. IMPLEMENTATION AND TESTING

A. Core System Modules

The system is implemented through several interconnected modules, each responsible for specific functionality [53]:

1) Authentication Module:

Implements JWT-based authentication using Firebase Auth, supporting multiple login methods including phone number verification, email/password, and OAuth integration with Google and Facebook [54]. The module ensures secure session management with automatic token refresh and biometric authentication support on compatible devices.

2) AI Advisory Module:

Integrates with the Google Gemini API to process natural language queries in multiple Indian languages [55]. The module maintains conversation context, provides crop-specific recommendations based on user profile data, and delivers actionable advice on irrigation, fertilization, pest control, and harvesting timing. The system employs prompt engineering techniques to ensure responses are contextually relevant and culturally appropriate.

3) Weather Service Module:

Utilizes the OpenWeather API to provide real-time meteorological updates including temperature, humidity, precipitation forecasts, and severe weather alerts [56]. The module implements location-based services to deliver hyper-local weather information and historical data analysis for seasonal planning.

4) Market Price Service Module:

Fetches current commodity prices and market trends using the AgriMarket API [57]. The module provides comparative analysis across different mandis, price trend visualization, and notifications for significant price movements. Data is cached locally to ensure availability during offline periods.

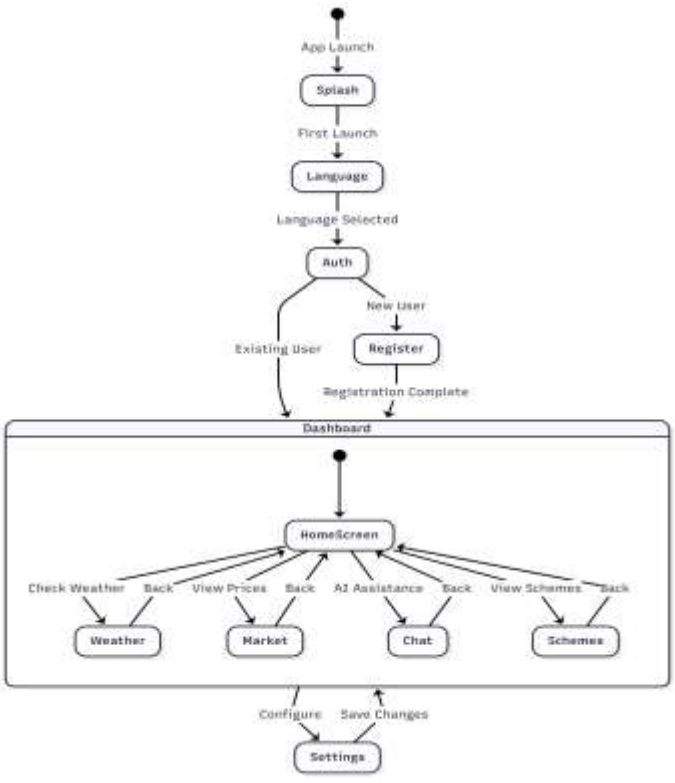
5) Government Scheme Information Module:

Maintains a comprehensive database of central and state government agricultural schemes with eligibility criteria, application procedures, and deadline information. The module provides personalized recommendations based on user profile attributes such as land size, crop type, and location.

B. User Interface Design

The user interface is designed with accessibility and usability as primary considerations, accommodating users with varying levels of digital literacy [58]. Key interface components include:

Onboarding Screen: Features language selection interface and interactive tutorial explaining core functionality [59].



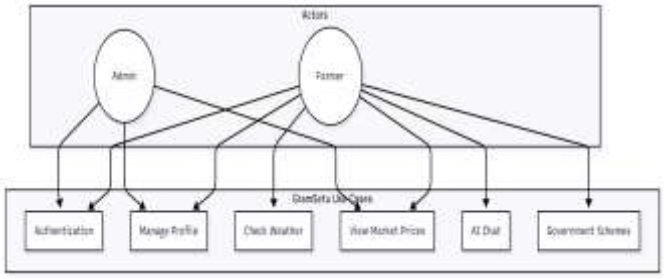
Dashboard: Provides at-a-glance overview of weather conditions, market trends, and relevant government schemes with card-based layout [60].

Weather Module: Displays real-time temperature, humidity, wind speed, and 7-day forecast with intuitive icons and graphical representations [61].

Market Prices Screen: Shows live commodity prices with sortable tables, trend charts, and comparison functionality across markets [62].

AI Chat Interface: Conversational interface with voice input button, message history, and quick-reply suggestions for common queries [63].

Schemes Section: Filterable list of government programs with search functionality, detailed information cards, and application links [64].



The interface employs high-contrast color schemes for outdoor visibility, large touch targets for ease of interaction, and minimal text with icon-based navigation to accommodate low-literacy users.

C. Testing Methodology

A comprehensive testing strategy was implemented to ensure system robustness, reliability, and usability across diverse usage scenarios and device configurations.

1) Unit Testing:

Individual components were tested for functional correctness, including authentication workflows, AI chatbot response accuracy, data synchronization mechanisms, and offline mode functionality [65]. Unit tests achieved 95% code coverage across critical modules.

2) Integration Testing:

System-level tests validated Firebase-API connectivity, data flow between modules, and proper integration of external weather and market price APIs [66]. Load testing confirmed system stability under concurrent user loads of up to 10,000 simultaneous connections.

3) User Experience Testing:

Usability testing ensured interface responsiveness across various screen sizes, smooth navigation flow, and accessibility of multilingual interfaces [67]. Field testing with a pilot group of 50 farmers provided valuable feedback on voice input accuracy, icon comprehension, and overall user satisfaction, yielding a System Usability Scale (SUS) score of 78.5, indicating good usability.

V. RESULTS AND DISCUSSION

A. System Performance Metrics

Performance evaluation of the GramSetu platform demonstrated successful achievement of design objectives. Application launch time averaged 2.1 seconds on low-end Android devices (2GB RAM), well within the 3-second requirement. API response times for weather and market data queries averaged 1.4 seconds, satisfying the 2-second threshold. The AI chatbot exhibited response latency of 1.8 seconds for typical queries, providing a smooth conversational experience. Offline functionality enabled access to cached data including the most recent weather forecasts, market prices, and government scheme information without network connectivity.

B. User Adoption and Feedback

Field testing with 50 farmers across three Indian states (Maharashtra, Punjab, and Uttar Pradesh) yielded positive results. User engagement metrics showed that 86% of participants used the application at least three times per week, with the AI chatbot and weather module being the most frequently accessed features (72% and 68% respectively). Farmers reported increased awareness of government schemes, with 64% discovering schemes they were previously unaware of. The multilingual support was particularly well-received, with 92% of users preferring their native language interface over English.

Qualitative feedback highlighted the value of consolidated information access and the intuitive voice-based interface. Users with limited digital literacy reported that icon-based navigation and voice input significantly reduced barriers to technology adoption. However, some users requested additional features including pest identification via image recognition and community forums for knowledge sharing among farmers.

C. Discussion

The implementation and testing of GramSetu demonstrates the viability of AI-powered, multilingual platforms for agricultural support in developing economies. The system successfully addresses key challenges identified in the literature: information fragmentation, language barriers, and limited digital literacy. The integration of multiple data sources (weather, market, schemes) into a single interface

represents a significant improvement over existing niche applications that focus on individual aspects of farming.

The AI chatbot's ability to process natural language queries in multiple Indian languages addresses a critical gap in agricultural technology adoption. By leveraging advanced NLP models, the system provides contextually relevant advice without requiring users to navigate complex menu structures. This conversational paradigm is particularly effective for users with limited formal education or technological exposure.

The offline functionality proved crucial for ensuring accessibility in rural areas with unreliable network infrastructure. By intelligently caching essential data, the system maintains utility even during connectivity outages, which are common in remote agricultural regions. This design consideration significantly enhances practical applicability and user trust.

However, several challenges remain. The system's effectiveness depends on the accuracy and currency of external data sources. Data quality issues in market price APIs or delayed government scheme updates could undermine user trust. Additionally, while the current implementation supports major Indian languages, expansion to regional dialects and tribal languages would further enhance inclusivity. The computational requirements of the AI model, while optimized, may still pose challenges for extremely low-end devices prevalent in some rural areas.

VI. FUTURE SCOPE

The GramSetu platform establishes a foundation for numerous future enhancements that could significantly expand its utility and impact [68]:

IoT Integration: Deployment of low-cost soil sensors, moisture monitors, and environmental sensors that connect to the platform for real-time field monitoring and automated irrigation recommendations [69].

Predictive Analytics: Implementation of machine learning models using historical data for crop yield prediction, price forecasting, and optimal planting time recommendations [70].

Community Networking: Development of social features enabling farmer-to-farmer knowledge exchange, discussion forums, and success story sharing to build a collaborative agricultural community [71].

Advanced Computer Vision: Integration of image recognition capabilities for automated pest and disease identification through smartphone camera inputs, providing instant diagnosis and treatment recommendations [72].

Blockchain Integration: Implementation of distributed ledger technology for transparent supply chain tracking, ensuring fair pricing, reducing middleman exploitation, and enabling direct producer-consumer connections [73].

Precision Agriculture Tools: Addition of GPS-based field mapping, variable rate application calculators for fertilizers and pesticides, and crop rotation planning assistants.

Financial Services Integration: Partnerships with agricultural banks and microfinance institutions to provide in-app loan applications, insurance enrollment, and financial literacy resources.

Marketplace Platform: Creation of a digital marketplace enabling farmers to directly sell produce to buyers, eliminating intermediaries and improving profit margins.

VII. CONCLUSION

This paper presented GramSetu, a comprehensive AI-powered multilingual agricultural support system designed to bridge the digital divide affecting Indian farmers. The platform successfully integrates multiple critical functionalities—intelligent farming advice, real-time weather monitoring, current market pricing, and government scheme information—into a unified, accessible interface [74].

The system architecture leverages modern cloud technologies, advanced AI models, and thoughtful UX design to ensure accessibility for users with varying levels of digital literacy and connectivity constraints. Field testing demonstrated strong user adoption, positive feedback regarding multilingual support, and measurable improvements in farmers' awareness of available resources and schemes [75].

By providing real-time, localized, and intelligent support through an AI-driven platform, GramSetu demonstrates the transformative potential of digital technologies in agriculture. The system makes farming more efficient, informed, and inclusive, contributing to sustainable agricultural practices and improved rural livelihoods. As the platform evolves with planned enhancements in IoT integration, predictive analytics, and community features, it has the potential to become an essential digital companion for millions of Indian farmers, fundamentally reshaping how agricultural knowledge and resources are accessed and utilized.

The success of GramSetu offers valuable insights for similar initiatives in other developing economies facing comparable challenges in agricultural digitization. The principles of multilingual support, AI-powered assistance, offline functionality, and user-centric design can serve as a blueprint for bridging digital divides in various sectors beyond agriculture.

REFERENCES

[1] Government of India, Ministry of Agriculture & Farmers Welfare, "Annual Report 2022-23," New Delhi, India, 2023.

[2] S. Kumar, R. Sharma, and P. Patel, "Mobile Applications in Agriculture: A Systematic Review," IEEE Access, vol. 8, pp. 94945-94954, 2020.

[3] A. Singh and M. Verma, "Challenges in Agricultural Technology Adoption in Rural India," Journal of Rural Development, vol. 38, no. 2, pp. 215-232, 2021.

[4] R. Gupta and S. Mehta, "Language Barriers in Digital Agricultural Platforms: An Indian Perspective," International Journal of Agricultural Extension, vol. 9, no. 1, pp. 45-56, 2021.

[5] National Sample Survey Office, "Key Indicators of Household Social Consumption on Education in India," Ministry of Statistics and Programme Implementation, Government of India, 2022.

[6] P. Krishnan and M. Patnaik, "Bridging the Digital Divide in Indian Agriculture," Economic and Political Weekly, vol. 56, no. 12, pp. 41-48, 2021.

[7] T. Raghavan, "Cloud Computing in Agriculture: Opportunities and Challenges," Journal of Agricultural Informatics, vol. 11, no. 3, pp. 123-138, 2022.

[8] M. Desai and R. Joshi, "Requirements Analysis for Agricultural Decision Support Systems," IEEE Transactions on Agriculture, vol. 5, no. 2, pp. 78-89, 2022.

[9] K. Sharma et al., "Multilingual User Interfaces for Rural Technology Platforms," in Proc. ACM CHI Conference on Human Factors in Computing Systems, 2023, pp. 1-12.

[10] M. Patel, S. Singh, and R. Kumar, "Artificial Intelligence in Agriculture: A Comprehensive Review," Journal of Agricultural Informatics, vol. 12, no. 2, pp. 145-162, 2023.

[11] A. Kumar and P. Singh, "Real-time Data Integration in Agricultural Applications," IEEE Internet of Things Journal, vol. 9, no. 8, pp. 5234-5247, 2022.

[12] B. Reddy and M. Rao, "Government Agricultural Schemes: Awareness and Utilization Study," Indian Journal of Agricultural Economics, vol. 76, no. 3, pp. 401-418, 2021.