Indian Journal of Agriculture Engineering (IJAE)
ISSN: 2582-9319 (Online), Volume-5 Issue-2, November 2025

Fertiflow- Emphasises Intelligent Automation and Data Flow in Agriculture

Kajal Ghule, Prajakta Sitap

Abstract: ***Agriculture, as a critical sector of the Indian economy, is increasingly benefiting from advancements in mobile and cloud-based technologies. This paper presents Fertiflow, a cross-platform agricultural application developed using Flutter and Firebase, designed to modernise the digital infrastructure available to farmers. Fertiflow leverages modern software engineering principles to deliver a modular and scalable solution that connects farmers with essential services, including market pricing, government schemes, agency support, and digital payments. The system architecture comprises key application modules, including Home Screen, Agency Screen, Profile Screen, Login Screen, Payment Screen, and dedicated components for Government MSP integration and Farming Tools access. Built on Firebase's real-time database and authentication services, the app ensures seamless synchronization, secure user management, and efficient data handling in low-connectivity rural environments. This paper examines the user interface design, component-based architecture, and backend integration strategy of the application, as well as the challenges of delivering reliable performance in resource-constrained settings. Additionally, it discusses the broader implications of Fertiflow in advancing rural digital transformation, highlighting how mobile-first software solutions can bridge the gap between traditional farming practices and emerging digital ecosystems. Fertiflow exemplifies the convergence of mobile computing, cloud services, and agricultural informatics, demonstrating how computer science can directly contribute to socio-economic development in rural sectors.***

Keywords: Home Screen, Agency Screen, Profile Screen, Login Screen, Payment Screen

Abbreviations:
MSPs: Minimum Support Prices
NAM: National Agriculture Market
DBR: Design-Based Research

I. INTRODUCTION

The agricultural landscape has undergone a significant transformation in recent years, driven by technological advancements and an increasing demand for digital inclusion in rural sectors.

Manuscript received on 21 April 2025 | First Revised Manuscript received on 07 May 2025 | Second Revised Manuscript received on 18 October 2025 | Manuscript Accepted on 15 November 2025 | Manuscript published on 30 November 2025.
*Correspondence Author(s)
Kajal Ghule*, Bachelor of Computer Application in (BCA-CT), Ajeenkya D Y Patil University, Pune (Maharashtra), India. Email ID: kajal.ghule@adypu.edu.in, ghulekajal11@gmail.com, ORCID ID: 0000-0002-2136-4060
Prof. Prajakta Sitap, Asst. Professor & Research Guide, Ajeenkya D Y Patil University, Pune (Maharashtra), India. Email ID: facultyit547@adypu.edu.in, ORCID ID: 0009-0005-9701-6168

As smartphones and internet access become more widespread among farming communities, digital platforms have emerged as powerful tools to support agricultural productivity, transparency, and efficiency.

Farmers, suppliers, and consumers alike are seeking more innovative ways to access essential resources, manage crop sales, and stay updated with government policies and pricing structures.

To meet these evolving needs, *Fertiflow* was developed as a comprehensive agricultural mobile application, designed to empower users through seamless access to fertilisers, tools, verified supply agencies, and crucial government data, such as Minimum Support Prices (MSPs). Built using Flutter and Firebase, Fertiflow offers features such as real-time product listings, secure user authentication, dynamic profile management, and integrated digital payments. By unifying these capabilities under a single platform, Fertiflow offers a tailored, user-friendly experience that enables farmers to make informed decisions, reduce operational burdens, and enhance overall efficiency. The inclusion of modules like the Government MSP screen and Tools for Farming further enhances the App's value, ensuring users have the information and resources they need at their fingertips.

[Fig.1: Agricultural Landscape]

II. RELATED WORK

Recent developments in agriculture have increasingly emphasized the role of digital technologies in transforming traditional farming practices. Several studies and platforms have explored the integration of mobile technologies to support farmers in accessing timely information, government services, and market trends.

A. Smart Agriculture with Mobile Applications

Many mobile-based agricultural platforms have been developed globally to assist farmers with weather updates, crop management, and subsidy tracking [1]. Applications like Kisan Suvidha and IFFCO Kisan have demonstrated the value of digital tools in enhancing agricultural productivity and

informed decision-making. These apps typically include features such as expert advice, market prices, weather forecasting, and crop protection alerts [2].

B. Digital Platforms for Government Schemes

The Indian government has made significant strides in providing digital access to services, including Minimum Support Price (MSP) announcements, fertiliser subsidies, and crop insurance. Platforms such as the **PM-Kisan portal** and **eNAM** (National Agriculture Market) enable farmers to access crucial financial benefits and market linkages digitally [3]. Fertiflow builds on this trend by directly embedding government MSP data within the app, allowing farmers to make informed crop-selling decisions [4].

C. Firebase and Flutter in Agri-Tech

Flutter has become a preferred framework for building high-performance, cross-platform apps due to its speed, modularity, and native UI rendering capabilities. Paired with **Firebase** for authentication, real-time database, and analytics, it enables rapid prototyping and scalable deployment [5]. Studies have shown that Firebase enhances data synchronization for real-time updates in low-bandwidth rural areas, making it a suitable choice for agriculture apps targeting remote users [6].

D. AI and IoT in Agriculture

Although Fertiflow does not currently utilise IoT or AI directly, research in this space suggests potential for future integration. AI models can aid in crop disease detection, yield prediction, and the automation of irrigation management [7]. IoT devices, such as soil sensors and drones, can provide live field data for processing and visualisation in mobile applications [8].

E. Challenges in Agri-Tech Adoption

Despite technological advancements, adoption in rural regions remains limited due to a lack of digital literacy, language barriers, and inadequate infrastructure [9]. Studies have stressed the importance of localised content, voice interfaces, and offline capabilities in mobile applications to ensure inclusivity [10].

III. LITERATURE REVIEW

[Fig.2: Accelerating Digital Inclusion]

A. Agri-Tech Evolution

The integration of mobile applications in farming is accelerating digital inclusion. Gupta et al. (2022) show how digital agri-apps enhance productivity and transparency.

B. Firebase as a Backend

Rao (2021) explains Firebase's ability to serve real-time updates with minimal server-side configuration, ideal for scalable apps like Fertiflow.

C. UI/UX for Rural Users

Naik & Mehta (2020) argue that clean, simple interfaces improve usability among farmers unfamiliar with complex digital systems.

D. Government MSP Awareness

According to Sharma (2023), farmers benefit significantly from having access to real-time MSP data. Digitizing this information increases accessibility and planning.

E. Digital Payments in Rural India

According to ICICI's digital survey (2022), Stripe and Razorpay are leading secure payment gateways that promote digital transactions in tier-2 and rural towns.

F. Role of Agri Apps in Crop Management

Patel & Joshi (2021) highlight that agricultural apps play a significant role in crop planning, disease detection, and pesticide recommendations. By offering real-time suggestions based on weather and crop data, these apps empower farmers to make more informed agronomic decisions, thereby reducing losses and enhancing yield quality.

G. Real-Time Databases and Cloud Integration

According to Bose et al. (2022), real-time databases like Firestore offer low-latency read/write operations, making them ideal for data-sensitive applications, such as agri-commerce, where order tracking, inventory, and MSP updates require instant synchronisation.

H. Agricultural Tool Digitization

A report by AgriTech World (2020) highlights that mobile platforms featuring farm tools, along with descriptions, images, and usage guidelines, increase awareness and adoption of modern farming equipment among rural farmers. This digitization boosts operational efficiency and modernises agricultural practices.

I. Multi-Module Mobile Applications

Khan and Sinha (2021) emphasise the importance of modular app design for agricultural platforms, suggesting that integrating modules such as profiles, marketplaces, advisory content, and payment systems within a single app improves user retention and simplifies workflows.

IV. METHODOLOGY

The development and evaluation of *Fertiflow* followed a structured methodology that combined system design, implementation, and qualitative user feedback to ensure the application met the real-world needs of its users, primarily farmers, suppliers, and agricultural consumers. A mixed-method approach was adopted that integrates both technical development practices and user-centred research principles.

A. Research Design

This study is based on a design-based research (DBR) methodology, which focuses on iterative design, testing, and refinement of the app. The process involved

gathering requirements, developing prototypes, implementing the system using Flutter and Firebase, and evaluating it through user testing.

The research process involved three key phases:

i. Planning and Design
ii. Development and Integration
iii. User Testing and Feedback

B. Data Collection Approach

To evaluate Fertiflow's performance and usefulness, feedback was gathered through structured methods:

i. *Surveys:* Distributed digitally to small groups of farmers, agri-students, and local traders and focused on usability, clarity, and usefulness of features.
ii. *Interviews:* Conducted with 10 early users to gather in-depth feedback on design, ease of use, and expectations.
iii. *App Usage Logs:* Firebase Analytics was used to track user engagement, screen views, and purchase activity.
iv. *Field Observations:* App testing was conducted in rural areas to observe real-world usage conditions and network responsiveness.

C. Target User Groups

Three categories of users were considered for this study:

i. *Farmers:* End-users seeking fertilisers, tools, and government updates.
ii. *Suppliers/Agencies:* Entities listed in the app offering products to farmers.
iii. *Students/Researchers:* Evaluators for design and functionality in an academic context.

D. Evaluation Metrics

The following metrics were used to evaluate Fertiflow's performance:

i. *App Load Time:* Measured with Flutter DevTools.
ii. *User Retention Rate:* Tracked via Firebase Analytics.
iii. *Payment Success Rate:* Analyzed through Razorpay/Stripe logs.
iv. *Crash Reports:* Captured via Firebase Crashlytics.
v. *User Satisfaction Score:* Based on a 1–5 rating collected through in-app surveys.

V. CHALLENGES AND LIMITATIONS

A. Internet Dependency: Fertiflow's reliance on real-time data necessitates stable internet connectivity. In regions with limited or inconsistent internet access, users may encounter difficulties accessing timely information, which can impact the app's effectiveness.

B. Security Concerns: Ensuring data security is paramount. Firebase's security rules must be meticulously configured to prevent unauthorised access to sensitive data. Any lapses could compromise user data, leading to trust issues and potential misuse.

C. Scalability: As the user base and data volume grow, Firestore's read/write operations could lead to increased costs and potential performance bottlenecks. Efficient data structuring and optimisation strategies are crucial for maintaining scalability.

D. Data Maintenance: Maintaining up-to-date information, especially regarding MSPs and product listings, requires regular updates. Delays or inaccuracies can misinform users, affecting their decision-making processes.

E. UI Testing on Diverse Devices: Ensuring a consistent user experience across various devices, including low-end smartphones and emulators, posed challenges. Responsive design adjustments were necessary to accommodate different screen sizes and resolutions.

F. Language and Localisation: Currently, Fertiflow primarily operates in English. To cater to a broader user base, particularly in rural areas, incorporating regional languages such as Marathi and Hindi is crucial. This requires additional development and localization efforts.

G. User Training and Adoption: Introducing new technology to users unfamiliar with digital platforms necessitates training and support. Without proper guidance, users may underutilise the app's features or encounter navigation difficulties.

H. Outcomes And Results

i. *User Feedback:* Beta testers rated Fertiflow 4.6 out of 5, highlighting its intuitive interface and the utility of features like the MSP screen. Users appreciated the app's role in simplifying access to agricultural information.
ii. *Performance Metrics:*
iii. *Login Time:* The average login time is recorded at under 2 seconds, ensuring quick access for users.
iv. *Product Loading Time:* Products load within approximately 1 second, facilitating efficient browsing.
v. *Payment Accuracy:* Integration with Razorpay yielded a 97% success rate for test transactions, demonstrating reliable payment processing capabilities.
vi. *Profile Module Functionality:* User profiles, including order histories and uploaded images, are accurately linked to Firebase Auth user IDs, ensuring personalized experiences and data integrity.
vii. *Impact on Farmers:* The MSP screen emerged as a particularly valuable feature, providing farmers with real-time government pricing data that aids in informed decision-making and financial planning.

VI. HYPOTHESES

The following hypotheses were developed to assess the effectiveness, user experience, and operational viability of the *Fertiflow* application. These are categorized into thematic groups that align with the study's objectives and design.

A. Hypotheses on User Engagement and Satisfaction

H1: *Users who access real-time Government MSP data are more likely to engage with the app regularly.*

- Rationale: Real-time pricing information builds trust and supports decision-making.

H2: *Fertiflow users will show higher satisfaction rates when the app is available in*

regional languages.

- Rationale: Localization improves usability and

H3: *An intuitive UI/UX will positively impact first-time user retention within the first 48 hours.*

- Rationale: Simple interfaces reduce cognitive load and improve early app adoption.

B. Hypotheses on Operational Performance and Technical Efficiency

H4: *Firebase-based real-time databases reduce response time in data fetching below 2 seconds on average.*

- Rationale: Cloud Firestore supports low-latency performance for scalable apps.

H5: *Stripe and Razorpay integrations improve payment success rates above 95% in rural transaction scenarios.*

- Rationale: Localized payment gateways support various user-preferred methods such as UPI and wallets.

H6: *Using Firestore to manage order and user data will result in fewer than 2% data sync errors.*

- Rationale: Firestore's real-time syncing and structured data storage improve accuracy.

C. Hypotheses on Feature Usefulness

H7: *The MSP screen is the most frequently accessed feature by users interested in crop pricing.*

- Rationale: Pricing data is highly relevant for farmers planning their crop sales.

H8: *The Tools for Farming screen will see higher engagement among agency partners and advanced users.*

- Rationale: This section provides essential resources for farm operations, extending beyond fertilisers.

H9: *Users who complete a successful payment are more likely to revisit the app within one week.*

- Rationale: Seamless transactions contribute to loyalty and trust in digital commerce.

D. Hypotheses on Digital Literacy and Accessibility

H10: *Users aged 18–35 will adapt to Fertiflow features faster than users above 50.*

- Rationale: Younger users are more digitally literate and open to using mobile apps.

H11: *Multilingual support will increase daily active users in rural areas by at least 30%.*

- Rationale: Language familiarity removes barriers to entry and comprehension.

H12: *Audio or visual tutorials will reduce the drop-off rates of first-time users.*

- Rationale: Visual learning aids users with low reading proficiency in understanding app usage.

E. Hypotheses on Market Adoption and Scalability

H13: *Apps with integrated marketplaces (tools + fertilizers) have higher retention than single-feature apps.*

- Rationale: Users prefer all-in-one solutions rather than managing multiple platforms.

H14: *Frequent updates to government data (e.g., MSP) improve app credibility and daily usage.*

- Rationale: Users trust platforms that reflect timely and accurate information.

H15: *Cloud-based apps like Fertiflow scale more efficiently than traditional server-based solutions in rural networks.*

comprehension among rural users.

Rationale: Firebase offers real-time syncing and distributed cloud infrastructurebd268

VII. CASE STUDIES

To better understand the design, features, and real-world relevance of Fertiflow, we reviewed and analyzed similar applications that serve agricultural communities. These case studies provide valuable insights into the technological choices, challenges, and user engagement strategies that influenced the development of Fertiflow.

A. Kisan Suvidha (India) Overview:

Developed by the Indian government, *Kisan Suvidha* is an app that provides information on weather forecasts, market prices, pesticide use, and crop advisories.

i. Features:

- Real-time weather updates
- Market price information from nearby mandis
- Expert advisory and crop protection tips
- Multilingual support

ii. Challenges:

- Outdated interface and occasional lag in data syncing
- No in-app e-commerce or agency connect options

iii. Impact:

- Popular in rural India for weather alerts and pricing info.
- Emphasized the need for intuitive design and real-time features, which Fertiflow integrates more effectively using Flutter and Firebase.

B. AgriApp (India) Overview:

A commercial app offering a comprehensive agri-ecosystem, including farm input shopping, crop advisory services, and agricultural news.

i. Features:

- Product purchasing and doorstep delivery
- Live chat with agri-experts
- Crop disease diagnosis with AI
- E-wallet support for payments

ii. Challenges:

- Requires constant internet and high device compatibility
- Relatively complex UI for first-time users

iii. Impact:

- Demonstrates a strong market for agri-commerce in India
- Inspired the Fertiflow team to add the Tools for Farming section for similar utility

VIII. CONCLUSION

Fertiflow emerges as a comprehensive, technology-driven platform tailored for the agricultural ecosystem. By integrating product

listings, government rate awareness, and secure transactions, it addresses the multifaceted needs of modern farmers. The app's lightweight architecture ensures scalability, positioning it well to adapt to the evolving demands of the agri-tech sector. Future enhancements, such as AI-driven recommendations and multilingual support, promise to further solidify Fertiflow's role in empowering the farming community.

Moreover, Fertiflow bridges the digital divide by making technology accessible to farmers, promoting financial inclusion and informed decision-making. Its intuitive interface and simplified navigation ensure ease of use.

For first-time smartphone users in rural regions. The integration of real-time data, such as crop trends and market prices, enables farmers to stay competitive and reduces dependency on intermediaries.

Fertiflow also lays the foundation for a broader ecosystem, where government schemes, weather updates, and innovative farming tools can be seamlessly integrated, transforming it into a one-stop solution for agricultural empowerment. By focusing on transparency, trust, and technology, Fertiflow not only enhances productivity but also contributes to the socio-economic development of rural populations.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/Competing Interests: Based on my understanding, this article does not have any** conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. Flutter Framework Google. (2024). *Flutter Documentation: Build beautiful native apps in record time*. Retrieved from https://flutter.dev/docs
2. Firebase Realtime Database Google Firebase. (2024). *Firebase Realtime Database Documentation*. Retrieved from https://firebase.google.com/docs/database
3. Firebase Authentication Google Firebase. (2024). *Firebase Authentication: Secure sign-in for any platform*. Retrieved from https://firebase.google.com/products/auth
4. Modular Architecture in Mobile Apps Haki, M. K., Legner, C., & Ahlemann, F. (2016). *Modularization of enterprise applications: Concepts, techniques, and challenges*. In Proceedings of the 24th European Conference on Information Systems (ECIS 2016). https://repositum.tuwien.at/bitstream/20.500.12708/13374/2/Vergara-Heinrroth%20Julio%20Cesar%20-%202008%20-%20Modularization%20of%20Enterprise%20Applications...pdf
5. Mobile UI/UX Design Principles Tidwell, J. (2019). *Designing Interfaces: Patterns for Effective Interaction Design* (3rd ed.). O'Reilly Media. https://www.amazon.in/Designing-Interfaces-3e-Jenifer-Tidwill/dp/1492051969
6. Cloud Computing in Mobile Applications Armbrust, M., et al. (2010). *A view of cloud computing*. Communications of the ACM, 53(4), 50–58. DOI: https://doi.org/10.1145/1721654.1721672
7. Information and Communication Technology (ICT) in Agriculture Mittal, S., Gandhi, S., & Tripathi, G. (2010). *The Socioeconomic Impact of Mobile Phones on Indian Agriculture*. Indian Council for Research on International Economic Relations (ICRIER). Retrieved from. https://www.researchgate.net/publication/46435402
8. Backend-as-a-Service (BaaS) Platforms Zhang, Q., Cheng, L., & Boutaba, R. (2010). *Cloud computing: state-of-the-art and research challenges*. Journal of Internet Services and Applications, 1(1), 7–18. DOI: https://doi.org/10.1007/s13174-010-0007-6
9. Cross-Platform App Development Malavolta, I., Ruberto, S., Soru, T., & Terragni, V. (2015). *End users' perception of hybrid mobile apps in the Google Play Store*. In Proceedings of the 2015 IEEE International Conference on Mobile Services (pp. 25–32). IEEE. DOI: https://doi.org/10.1109/MobServ.2015.12
10. Digital Transformation in Agriculture Klerkx, L., Jakku, E., & Labarthe, P. (2019). *A review of social science on digital agriculture, smart farming and agritech*. NJAS - Wageningen Journal of Life Sciences, 90-91, 100315. DOI: https://doi.org/10.1016/j.njas.2019.100315

AUTHOR'S PROFILE

Kajal Ghule. She is currently pursuing a Bachelor of Computer Applications – Cloud Technology at Ajeenkya D Y Patil University, Pune, India. She is part of the Batch 2022–2025 and is passionate about exploring emerging technologies in Application Development, Flutter. Her areas of interest include software development and App Development. Kajal is keen on developing practical, impactful solutions through interdisciplinary research and innovation. This research paper is part of the Fertiflow project, reflecting her ongoing efforts to gain deeper insights into Fertiflow, an agricultural application.

Prajakta Sitap is an Experienced academic professional with a B.Tech and M.Tech in Computer Science and Engineering. Proficient in data science, specializing in machine learning and deep learning. Conducted research on the semantic segmentation of crop types using remote sensing data during M.Tech. Additionally, well-versed in full-stack development with a comprehensive understanding of modern web and software development practices.