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Understanding Pineapple Farmers' for an Effective Pineapple Mobile App in Umling District of Meghalaya

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Abstract: Pineapple cultivation supports the livelihood of thousands of farming households in Meghalaya, yet farmers face persistent challenges related to crop management, market access and information sharing. The growing penetration of smartphones in rural areas presents an opportunity to bridge these gaps through the design of a mobile application grounded in clear understanding of farmers constraints and priorities in using technology. This study systematically investigates the challenges faced by pineapple farmers in Umling district of Meghalaya using the Analytical Hierarchy Process (AHP). A purposive sample of 100 farmers from two villages participated in structured pairwise-comparison exercises spanning six domains: technological, user experience and interface design, data and content quality, economic, support and training and knowledge and education. The results indicate that user interface and design constraints (0.460) and technological constraints (0.359) are the critical barriers. Key problems identified through local priority score includes language barriers, especially the absence of khasi language support (0.430), lack of near real time market information (0.308), inadequate training (0.479) and low digital literacy (0.480). The overall pairwise inconsistency ratio is 0.08 confirming the internal reliability of farmers judgements. The findings highlight the importance of localized, user-friendly and context-specific mobile applications. The study recommends the development of scalable and farmer-centric digital solutions to enhance agricultural productivity and market access.

Keywords: Analytic Hierarchy Process • Constraints • Pineapple Mobile App • Meghalaya.

Introduction

Advancements in digital technology have reshaped agricultural value chains across the developing world, with mobile applications emerging as one of the most accessible and impactful tools for smallholder farmers (Aker and Ksoll 2019). In India, smartphone penetrations has expanded rapidly into rural areas creating new pathways for delivering market intelligence, agronomic advisory services and peer-to-peer knowledge exchange. Meghalaya has witnessed a growing interest in integrating technology with more than 88,000 registered smartphone adroit farmers (1917iTEAMS 2022) and the Government of Meghalaya has actively promoted technology adoption through the Technology Mission for the Integrated Development of Horticulture. According to the Directorate of Economics and Statistics, Government of Meghalaya (2021), Meghalaya successfully produced 138,701 metric tonnes of pineapple over 11,367 hectares in the 2019–20 achieving productivity of 12-15 MT/ha that exceeds the Northeast Region average. Globally, Pineapple India has sixth position in production (1.34 million tonnes annually) hinting towards huge export potential with growing shipment at 9.78% CAGR to key markets like UAE and Nepal. Despite moderate competitiveness (NPC 0.53) Meghalaya's high-quality, organic pineapples has huge market demand and worldwide reach to boost farmer incomes via better market access and reduced gluts. (Akshatha *et al* 2024).

Despite this prominence, pineapple farmers face structural barriers including fragmented market linkages, limited access to agronomic information and inadequate post-harvest infrastructure that constrain productivity and income. To harness the potential of digital technology for profitability, the concept of developing mobile applications according to their needs has emerged. However, apps that are designed without adequate understanding of end-user's contexts frequently fails to achieve adoption. Participatory and user-centered design approaches are therefore critical to producing digital tools that create genuine value (Shaktawat and Swayamprava 2024). The study addresses the gap by systematically mapping and prioritising the constraints that pineapple farmers perceive as most significant in developing an effective mobile application.

The present study pursues two specific objectives: (i) To identify the major problem domains relevant to pineapple farmer adoption of a mobile application and (ii) To determine the relative priority of individual problems within each domain using the Analytical Hierarchy Process (AHP).

Material and Methods

Research Design: A diagnostic research design was employed for the study and is particularly suited for understanding the underlying nature and root causes of a specific problem rather than measuring the outcomes of any intervention. This approach is oriented toward answering foundational questions, specifically identifying "*what the problem is?*" and *"why it exists?"* in the context of pineapple farmers' experiences with mobile application interfaces. Such a design is appropriate when the researcher's primary objective is problem identification and characterization rather than treatment evaluation (Kerlinger 1996).

Study Area: The study was conducted in the Umling C&RD Block of Ri-Bhoi District, Meghalaya. This block was deliberately chosen on account of its prominence as a highly pineapple cultivating area and its ability to represent the wider agro-climatic and socio-economic realities faced by marginal cultivators across the district. Two villages: Marngar and Mawphrew were chosen as study areas based on their active pineapple farming communities. A total of 100 farmers were selected purposively based on the farmers fulfilling the two criteria of respondents, (i) farming experience (subject to a minimum of 5 years) reflecting sufficient engagement with crop management and market activities to offer informed judgements about digital tool needs and (ii) a maximum of 50 years of age to ensure respondents had sufficient familiarity with smartphones and basic digital interfaces, a threshold justified by national survey data indicating that digital literacy declines sharply beyond this age cohort in rural north-eastern India (1917iTEAMS 2022). The relatively small sample is consistent with AHP methodology for prioritises the quality of expert judgement over statistical representativeness (Saaty 1980; Ananda and Herath 2003).

Study Analysis: The analytical framework adopted in this study was the Analytic Hierarchy Process (AHP), executed across three sequential stages.

Stage 1: Problem Identification: A comprehensive recording of potential problems relating to the Pineapple Farmer's preference on the Interface of Mobile Applications are identified.

Stage 2: Pair-wise comparisons of problems: The stage involved conducting pairwise comparisons of the identified problems within each interface-related category. Each problem was evaluated against others within its domain and individual priority values were derived using the Eigen value method. Problems were further grouped into six thematic domains: Technological Problems, User Experience and Design Problems, Data and Content Problems, Financial Problems, Support and Training Problems, and Knowledge and Education Problems.

Stage 3: Global Priority calculation and consistency verification: In the final step, Scaling problems weights and local priority values of problems are used to calculate the overall or global priority of each problem as shown in formula below:

Global/Overall priority of problems$_{ij}$ = (Local Priority value of problem$_{ij}$) × (scaling weights of mobile applications category)

Where, i = number of problems in a mobile applications category, j= 6 (Technological, User Experience and Design, Data and Content, Financial, Support and Training, and Knowledge and Education problems)

For the pairwise comparison exercise, respondents were asked to evaluate each problem relative to others within the same domain using a nine-point prefernce scale (Table 1) proposed by Saaty (1977, 1980) as detailed.

Table 1. Pair-wise comparison scale on AHP predilections

Anchored Rating	Judgment of preferences
1	Equally Preferred/importance
2	Equally to Moderately Preferred
3	Moderately Preferred
4	Moderately to Strongly Preferred
5	Strongly Preferred
6	Strongly to Very StronglyPreferred
7	Very Strongly Preferred
8	Very Strongly to ExtremelyPreferred
9	Extremely Preferred

From each thematic domain, the problem registering the highest local priority value was identified as the domain representative. The scaling weights derived from the six domain-level comparisons were subsequently applied to calculate the global priorities of all individual problems contained within them, enabling a comprehensive, hierarchically structured ranking of the challenges faced by pineapple farmers in their use of mobile application interfaces.

Consistency Ratio (CR) Verification

A critical requirement of AHP is that respondents' pairwise judgements must demonstrate an acceptable degree of internal consistency. To verify this, the Consistency Ratio (CR) was calculated for each comparison matrix following the procedure established by Saaty (1977). The CR is derived from two intermediate measures: the Consistency Index (CI) and the Random Index (RI).

Consistency Index (CI):

$$CI = \frac{(\lambda max - n)}{(n - 1)}$$

λmax = maximum (principal) eigenvalue of the comparison matrix

n = number of criteria (matrix dimension)

Consistency Ratio (CR):

$$CR = \frac{CI}{RI}$$

RI = Random Index (average CI of randomly generated reciprocal matrices of order n)

A CR value of 0.10 (10%) or below is considered acceptable, indicating that the judgements are sufficiently consistent. Where CR exceeds this threshold, respondents were requested to revise their pairwise comparisons. Only matrices satisfying the CR ≤ 0.10 criterion were retained for final priority weight computation. This procedure ensures that the resulting priority vectors reliably reflect the relative importance assigned by pineapple farmers to each problem domain and sub-problem, thereby lending methodological rigour to the AHP-based ranking (Saaty 1980).

Results And Discussion

The analysis identified six major problem domains influencing pineapple farmers' adoption of mobile applications, as illustrated in Fig. 1. These domains were derived from existing literature (Syiem and Raj, 2015; Radha *et al.*, 2018; Chauhan *et al.*, 2019; Shaktawat and Singh, 2024) and comprise: (A) Technological constraints, encompassing four sub-criteria (T1–T4), (B) UX and Design shortcomings, with eight sub-criteria (UD1–UD8), (C) Data and Content deficiencies, covering six sub-criteria (D1–D6), (D) Financial barriers, with three sub-criteria (F1–F3), (E) Support and Training gaps, comprising three sub-criteria (ST1–ST3) and (F) Knowledge and Education deficits with four sub-criteria (KE1–KE4). Collectively, these six domains encompass 28 sub-criteria barriers. UX and Design emerged as the most sub-criterion-dense domain, reflecting the complexity of interface-related challenges faced by smallholder farmers with limited digital literacy. The structured classification provides a comprehensive hierarchical framework that serves as the foundation for subsequent AHP-based prioritization.

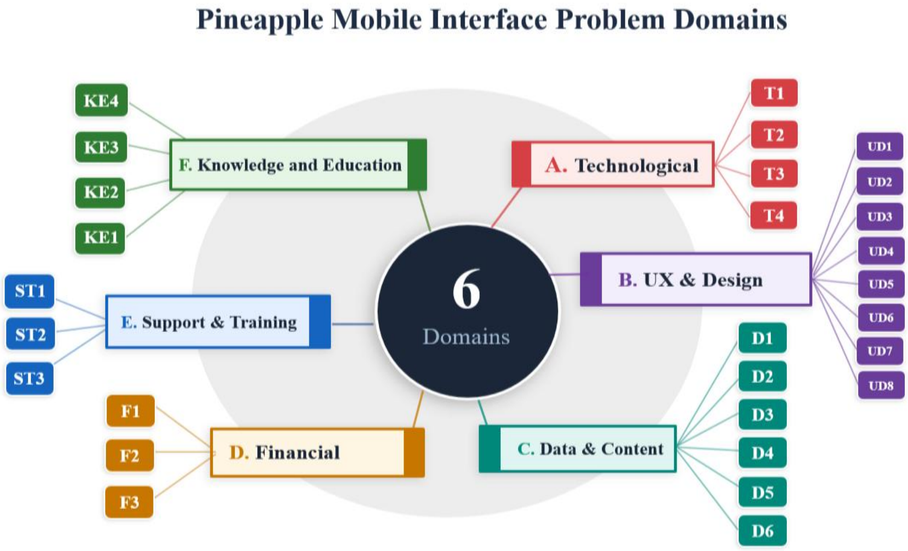

Fig. 1. Major problem domains influencing pineapple farmers' adoption of mobile applications

To address Objective 2, farmers conducted structured pairwise comparisons across all identified challenges, generating reliable local priorities (eigenvalue-derived) and domain scaling factors for global rankings, with inter-domain CR=0.030 confirming judgment consistency. Fig. 2, Fig. 3 and Table 2 illustrate their interconnections enabling precise intervention targeting to boost app adoption among pineapple smallholders. This AHP hierarchy reveals UX/design (0.460) and technological barriers (0.359) as dominant, underscoring usability over infrastructure alone. The table 2 validates Objective 2 by quantifying farmer-perceived obstacles, aligning with Meghalaya's digital agriculture needs.

Table 2. List of agreed-upon Pineapple Mobile Interface problems, local and global priority scores, and respective inconsistency ratios* on pair-wise comparison amongst problems [#] of each domain and between problems of domains of Pineapple Mobile Interface problems by implying AHP

Pineapple Mobile Interface domain & their problems		Local priority scores of factors	Inconsistency Ratio	Global priority scores
A.	**Technological problems**			**0.359**
T1	Limited access to up-to-date market information about market trends, potential buyers and distributors.	**0.308**	0.025	0.186
T2	Incompatibility with older device models or operating systems	0.295		0.112
T3	Aware of modern farming methods, but I find it hard to adopt them	0.229		0.043
T4	Unreliable or limited internet connectivity in rural areas.	0.168		0.018
B.	**User experience and Design problems**			**0.460**
UD1	Language barriers if the app is not available in the local language (khasi).	**0.430**	0.024	0.082
UD2	Farmers lack step-by-step guidance on tasks like setting up irrigation schedules or identifying specific pineapple diseases, resulting in avoidable mistakes.	0.313		0.036
UD3	Complex or unintuitive user interface design, causes farmers to miss crucial updates.	0.160		0.029
UD4	It is difficult to perform tasks due to the interface design's lack of clarity in terms of its elements and features.	0.014		0.023
UD5	Navigating through the interface is confusing.	0.012		0.011
UD6	I usually get lost or confused while using the platform's navigation.	0.038		0.105
UD7	The colours and visuals used on the platform are not aesthetically pleasing.	0.024		0.078
UD8	Slow loading times and frequent crashes discourage farmers.	0.009		0.096
C.	**Data and Content problems**			**0.122**
D1	Inaccurate or outdated agricultural advice provided by the app.	0.106	0.030	0.018
D2	Lacks an interactive map feature that allows pineapple farmers to locate nearby agricultural supply stores in Meghalaya.	0.226		0.024
D3	Inadequate support for capturing local practices and indigenous knowledge.	0.116		0.056
D4	App content is not tailored to the specific climate, soil conditions, and practices of the region.	**0.330**		0.011
D5	Lacks recording and accessing data on fertilizer usage and its impact on pineapple yields in Meghalaya.	0.140		0.009
D6	lack of variety in the types of content available for agricultural guidance.	0.078		0.004
D.	**Financial (Economic) problems**			**0.042**
F1	Lack of perceived return on investment for farmers, especially small-scale ones.	**0.428**	0.070	0.026
F2	App requiring paid subscriptions, data usage fees, or expensive devices.	0.356		0.011
F3	The app provides an online marketplace where pineapple growers in Meghalaya can directly connect with buyers, cutting out middlemen.	0.316		0.005
E.	**Support and Training problems**			**0.030**
ST1	Insufficient training is provided to farmers on how to effectively use the mobile app.	**0.479**	0.061	0.016
ST2	Limited ongoing technical support or troubleshooting assistance.	0.282		0.009
ST3	The quality of agricultural training is poor	0.239		0.005
F.	**Knowledge and Education problems**			**0.093**
KE1	Lacks educational qualifications to understand the features and usage patterns of mobile apps.	**0.480**	0.029	0.048
KE2	Lack of awareness about the app's benefits and features.	0.302		0.030

Pineapple Mobile Interface domain & their problems		Local priority scores of factors	Inconsistency Ratio	Global priority scores
KE3	Knowledge exchange among different stakeholders of pineapple marketing is limited.	0.136		0.011
KE4	a shortage of collaborative learning opportunities among educators.	0.082		0.004
*The inconsistency ratio of the pair comparison between the domains of Farmer's preference on pineapple mobile app problems was 0.030. The greatest weight with respect to each domain of problems of Farmer's preference on the pineapple mobile app was underlined.				

Technological Problems

Within the Technological Problems domain (domain scaling factor 0.359), farmers assigned the highest local priority to T1: limited access to current market information on prices, potential buyers and distribution channels (local priority score 0.308, Fig. 2); global priority score 0.186, Fig. 3). This was followed by T2 (incompatibility with older devices, 0.295) and T3 (difficulty adopting modern farming methods, 0.229. The Inconsistency Ratio for this domain was 0.025, confirming reliable judgements. This finding is directly corroborated by Singh *et al.* (2019) that real-time market linkage functionality was among the highest-valued features demanded by farmers in the northeastern states. Critically, this demand remains unmet for pineapple cultivators in Ri-Bhoi District, where fragmented market chains and the dominance of intermediaries structurally suppress price realisation. The Government of India's Digital Agriculture Mission launched with an outlay of Rs. 2,817 crores in September 2024 (PIB, 2024), explicitly identifies real-time market price information as a core farmer-centric digital service to be delivered through the AgriStack framework an acknowledgement at the highest policy level that technological exclusion from market information constitutes a systemic failure. Further, the rural tele-density of only 59.19 percent as of March 2024, compared to 133.72 percent for urban areas, quantifies the connectivity divide that underpins T4 (unreliable internet connectivity) in the present study, confirming that infrastructure deficits in northeast India remain structurally acute despite national digital inclusion initiatives (Syiem and Raj 2015; Paul *et al* 2017).

User Experience and Design Problems

Domain constituted the highest-weighted domain overall (scaling factor 0.460), reflecting farmers' paramount concern with whether an application is usable in their everyday context. Among the eight problems in this domain, UD1: The absence of Khasi language support has received the highest local priority score, 0.430 (Fig. 2); global priority 0.082, (Fig. 3). This was followed by UD2 (absence of step-by-step guidance, 0.313) and UD3 (unintuitive interface design, 0.160), and CR for domain was 0.024. The primacy of language accessibility in the mobile app is strongly validated by Singh *et al* (2019) and Lahiri *et al* (2024) that the multilingual architecture of digital platform was decisive in achieving the positive farmer response rate observed in its feedback system. The result amplifies this importance of language inaccessibility not as a peripheral usability concern but the structurally dominant barrier to app adoption among Khasi-speaking pineapple farmers of Ri-Bhoi (Gupta *et al* 2024 and Adla *et al* 2025).

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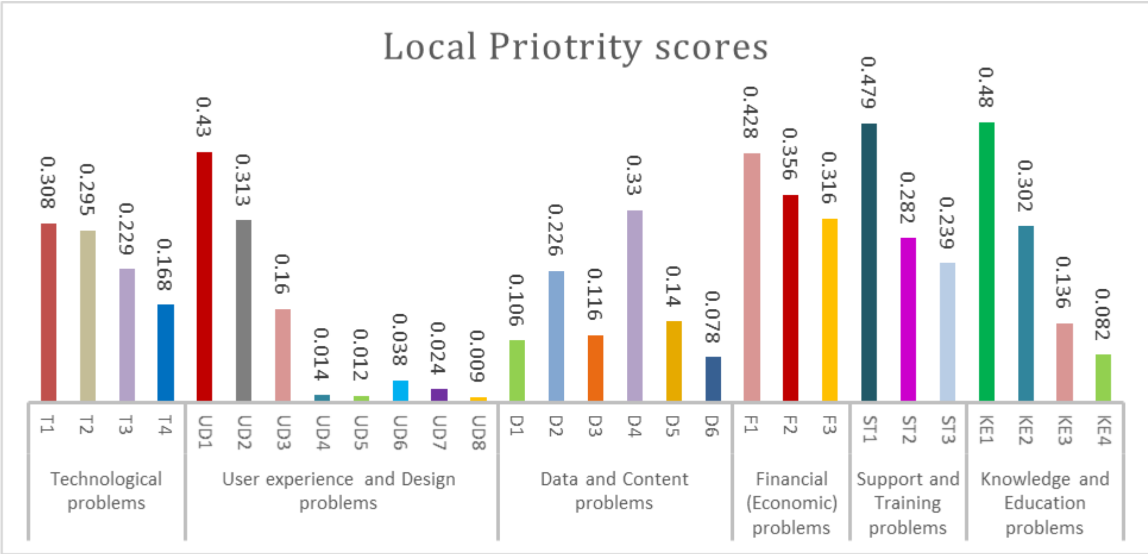

Fig. 2. Farmers' preference for pineapple mobile interface problem analysis for local Priorities

Data and Content Problems

The domain carried a scaling factor of 0.122. Within this domain, D4: content not tailored to the region's specific climate, soil conditions and agronomic practices has achieved the highest local priority (0.330, Fig. 2; global priority 0.011, Fig. 3). Followed by D3 (inadequate support for capturing local and indigenous knowledge, 0.116) attained the highest global priority within this domain (0.056) by virtue of its interaction with the domain scaling weight. The domain CR was 0.030. The pronounced preference for region-specific over generic agronomic content is substantiated by evidence from Radha *et al* (2018), established that the effectiveness of advisory content was critically contingent on its grounding in the micro-climatic conditions, indigenous farming calendars and specific cultivar attributes of the target community. Meghalaya's 2023 State Organic and Natural Farming Policy further underscores this point by explicitly recognising that farming in the state is organic and natural by tradition, and that the most productive agricultural advisory will be that which integrates and amplifies existing indigenous knowledge rather than displacing it with standardised national content (Government of Meghalaya, 2023). The Ri-Bhoi district pineapple system, characterised by lateritic soils, high rainfall variability, and a specific growing calendar distinct from other pineapple-producing states such as Kerala or Assam, demands hyper-local content that is co-developed with farmers rather than adapted from external databases. The current study's quantification of D4 (0.330) and D3 (0.116) as the two highest-priority content barriers provides empirical validation of this long-recognised but often under implemented principle in agri-tech design for northeastern India (Shaktawat and Singh, 2024; Lahiri *et al.*, 2024).

Financial Problems

The dominant problem was F1: perceived low return on investment for smallholder farmers (local priority 0.428, Fig. 2; global priority 0.026, Fig. 3), followed by F2 (costs related to subscriptions, data or devices, 0.356) and F3 (limited marketplace functionality, 0.316). The domain CR was 0.070 with a relatively lower scaling factor (0.042). The relatively lower domain weight of financial concerns should not be interpreted as an indication that economic barriers are peripheral. The Meghalaya Livelihoods and Access to Markets Project (Megha-LAMP) has specifically identified the absence of market linkage and price transparency as the primary barriers to income improvement for pineapple and horticulture farmers in the state that directly

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corroborates the prominence finding of F3 (limited marketplace functionality) in the present study (Government of Meghalaya 2023).

Support and Training Problems

The Support and Training domain (scaling factor 0.030) was ranked fifth in terms of overall domain weight. ST1: insufficient farmer training on effective app use was the most critical problem within the domain (0.479, Fig. 2; global priority 0.016, Fig. 3) followed by ST2 (limited technical support, 0.282) and ST3 (poor quality of training, 0.239). The domain CR was 0.061. Similarly, Lahiri *et al* (2024) in their study observed that sustained digital extension outreach required human intermediation as a structural support layer not merely a transitional aid. This directly validate ST1's high priority in the current study for tribal, smallholder farming communities in linguistically marginalised regions, self-directed app learning is not a realistic adoption pathway, and any deployment strategy (Abiha and Shukla 2024).

Knowledge and Education Problems

The Knowledge and Education domain (scaling factor 0.093) was ranked third in global terms. KE1: farmers lacking the educational background to understand app features was the highest-priority problem (local priority 0.480, Fig. 2; global priority 0.048, Fig. 3) followed by KE2 (low awareness of app benefits, 0.302), KE3 (limited knowledge exchange among stakeholders, 0.136), and KE4 (shortage of collaborative learning opportunities, 0.082). The domain CR was 0.029. The Government of India's Digital Agriculture Mission 2024 (PIB, 2024) explicitly acknowledges this challenge, noting that language barriers and low digital literacy together constitute the two most significant systemic obstacles to achieving the mission's goal of creating digital identities and providing farmer-centric advisory services for 11 crore farmers by 2026-27 targeted capacity-building investments. The quantification of KE1 at 0.480 provides evidence-based demand-side confirmation that these structural barriers are acutely felt by the farming community itself. Extension-led digital literacy campaigns, possibly delivered through existing farmer producer organisations or self-help groups, are recommended as a complementary strategy alongside app development (Chauhan *et al.*, 2019).

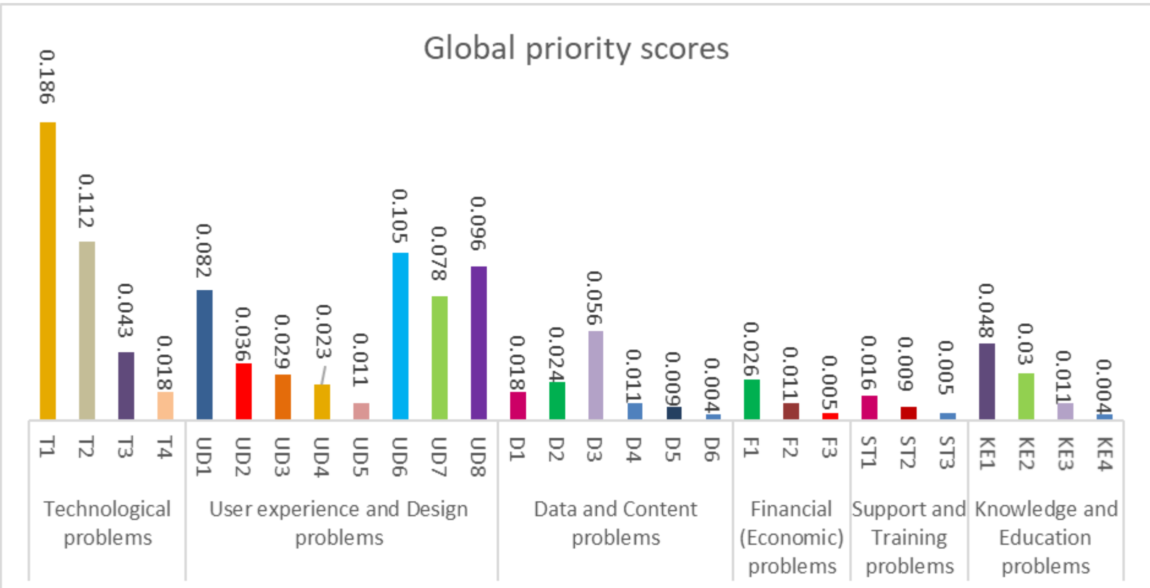

Fig. 3. Farmers' preference for pineapple mobile interface problem analysis for Global Priorities

The study identified language accessibility (UD1: 0.430; domain weight: 0.460) as the most critical barrier to digital adoption, consistent with findings of Gupta et al (2024), who reported that language mismatches significantly reduced farmers' use of digital advisory services. In Umling District, digital platforms available only in English or Hindi were not viewed merely as inconvenient but as exclusionary, preventing many farmers from engaging with digital technologies. This issue is particularly significant in Northeast India, where linguistic diversity shapes rural life and the absence of mother-tongue interfaces effectively excludes farming communities from agricultural digitization. Language barriers are further intensified by poor internet connectivity and complex user interfaces, creating a reinforcing cycle of digital exclusion. Similar patterns were observed by Cerjak et al (2025) among smallholder farmers in South India, where weak connectivity, language gaps, and limited digital literacy collectively constrained adoption.

The present study also highlights the interdependence of technological and design-related barriers, with Technological Problems and User Experience and Design Problems together accounting for a combined domain weight of 0.819. This indicates that addressing a single barrier in isolation is unlikely to ensure meaningful adoption. Studies by Chauhan et al (2019) and Shaktawat and Swayamprava (2024) similarly emphasized the importance of sustained extension support for regular platform use. Community facilitation, peer-based digital learning, and continuous updates based on farmer feedback are therefore essential (Lahiri et al 2024; Syiem and Raj 2015; Shaktawat and Singh 2024). Additionally, the high priority assigned to perceived low financial return (F1: 0.428) suggests that long-term adoption depends on demonstrating economic value. Hence, a phased strategy prioritizing accessibility and usability before introducing advanced economic features appears most suitable for achieving digital inclusion among smallholder farmers in the region.

Conclusion and Recommendation

The study contributes valuable empirical evidence on farmer-prioritized challenges in digital agricultural interfaces. The barriers don't operate in isolation rather are compound effect from multiple barriers and concludes that for an effective mobile application prioritizing user-centric design, local language integration and near real-time market information are important. While technological and economic barriers exist, the most critical challenges lie in usability and accessibility. The application of AHP provides a structured framework to prioritize farmer needs. However, future researches should validate these findings across larger sample and diverse pineapple-growing regions. Developers and researchers should focus on localized content, training programs and inclusive digital strategies to improve adoption and impact among users.

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