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Voice-Based Agricultural Advisory Services for Low-Literacy Users

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Abstract

Digital agricultural advisory services can reduce the distance between farmers and timely information on weather, crop management, pests, inputs, livestock, market conditions, and climate-related production risks. However, text-intensive digital extension can reproduce existing inequalities when farmers have limited reading proficiency, use basic mobile phones, communicate primarily in local spoken languages, or share devices within households. Voice-based advisory systems offer an alternative by delivering agricultural information through recorded audio, interactive voice response, toll-free helplines, expert callbacks, and farmer-to-farmer voice forums. This paper develops a conceptual–methodological framework for designing voice-based agricultural advisory services specifically for low-literacy users. The framework integrates five accessibility dimensions: spoken-language relevance, cognitive simplicity, interaction and replay capability, contextual personalization, and trusted human escalation. Prior research demonstrates that voice-based agricultural services can generate substantial farmer demand, alter information-seeking behavior, support technology adoption, and facilitate peer knowledge exchange; however, service effectiveness depends strongly on message timing, language, network reliability, content relevance, trust, and opportunities for interaction.

The study therefore rejects the assumption that replacing text with recorded speech is sufficient to achieve inclusive digital extension. A scenario-based analysis compares text-only messaging, generic voice broadcasting, local-language audio, interactive voice response, and personalized voice systems with expert callback capability. Because no original farmer dataset was provided, all quantitative values are explicitly simulated and are not presented as empirical findings. The analysis suggests that voice systems become progressively more accessible when farmers can replay information, navigate simple menus, receive locally relevant advice, and request clarification from trusted agricultural experts. The proposed framework offers a basis for future field experiments, usability studies, gender-sensitive access assessments, and agricultural-extension evaluations.

Keywords: voice-based agricultural advisory, low-literacy farmers, interactive voice response, agricultural extension, digital agriculture, mobile advisory services, rural communication, smallholder farmers

1. Introduction

Agricultural decision-making depends on information that is highly contextual and often time sensitive. Farmers may require guidance concerning crop varieties, planting dates, irrigation, fertilizer application, pest outbreaks, disease symptoms, livestock management, rainfall forecasts, harvesting, storage, and changing market conditions. Conventional face-to-face extension can provide valuable contextual interpretation but frequently faces limitations related to staffing, travel costs, geographical coverage, and the number of farmers one extension worker can support. Aker's review of information and communication technologies in agricultural extension identified mobile communication as a potentially important mechanism for widening information access while also emphasizing that the benefits of ICT depend on program design, information relevance, and users' ability to act on received advice.

The expansion of mobile communication does not remove all information-access barriers. Many digital agricultural programs depend heavily on written messages, menus, websites, smartphone applications, or data dashboards. These delivery modes can be difficult for farmers with limited reading proficiency and can also create challenges where agricultural terminology is not easily understood in standardized written language. More broadly, Medhi, Sagar, and Toyama demonstrated that low-literacy users benefit from interfaces designed around non-textual interaction, voice feedback, consistent assistance, and simplified navigation rather than interfaces that merely reduce the amount of written text. Voice-based agricultural advisory services extend this principle to rural extension by allowing farmers to obtain information through familiar spoken communication using ordinary telephones.

Evidence from agricultural voice systems demonstrates the potential value of this approach. Patel and colleagues' field study of Avaaj Otalo, an interactive voice forum serving small farmers, found that users valued the ability to ask agricultural questions, listen to responses, and hear other farmers' discussions. The study also observed that relatively simple menu navigation could be learned by users and that keypad-based selection performed effectively within the voice interface. Later evaluation of a voice-based agricultural advisory service found substantial demand for agricultural information and changes in farmers' information sources and recommended input use, although systematic improvements in yields and profitability were not established across all outcomes. These findings are important because they show both the promise and the limits of digital advice: information accessibility can influence behavior without guaranteeing production or income effects.

Voice delivery itself is not automatically inclusive. The Direct2Farm experience demonstrated that mobile advisory services can reach farmers at substantial scale and can influence adoption of agricultural practices, yet it also identified barriers related to gender, age, literacy, language, message timing, and control of mobile phones. Some voice messages were not listened to fully, and farmers could miss calls when timing or network reception was unsuitable. These observations suggest that an inclusive voice service should offer more than one-way automated calling. Replay, call-back access, user-controlled timing, short message structures, familiar vocabulary, simple navigation, and human clarification can be essential to practical usability.

The present study therefore examines how voice-based agricultural advisory services can be designed around the communication requirements of low-literacy users rather than around the technical capabilities of the delivery platform. It develops an accessibility framework connecting spoken-language clarity, interface simplicity, contextual relevance, interactive support, and trust. Low literacy is treated as a design consideration rather than a deficiency in agricultural knowledge; farmers may possess sophisticated experiential expertise while preferring oral communication to written digital interfaces. The paper is conceptual and methodological because no primary farmer dataset has been supplied. Its quantitative analysis uses transparent simulated scenarios to generate propositions that can subsequently be tested through field deployment, randomized evaluation, participatory design, and usability research.

2. Objectives of the Study

2.1 To Develop an Audio-First Agricultural Advisory Framework

The first objective is to develop a framework in which agricultural advisory information is designed from the outset for spoken communication. Audio-first design differs from simply reading a written extension message aloud. Written advisories may contain long sentences, numerical details, technical terminology, or several recommendations in one message. When delivered through voice, such material can create excessive memory demands because the user cannot visually scan backward through the information.

An audio-first advisory should therefore use concise spoken segments, familiar agricultural vocabulary, locally appropriate pronunciation, meaningful pauses, clear sequencing, and explicit action statements. Important numerical information should be repeated where appropriate, while technically complex recommendations should provide an option for additional explanation. The objective is to reduce communication burden without oversimplifying agronomic content.

2.2 To Identify the Design Conditions That Convert Voice Access into Actionable Advice

The second objective is to determine which service features are likely to make voice information practically usable. Accessibility includes more than hearing a message. Farmers must be able to understand the information, determine whether it applies to their farm, recall the recommendation when needed, and obtain clarification if uncertainty remains.

The study therefore evaluates five critical conditions: local-language delivery, simple interaction, replay capability, farmer-specific personalization, and access to trusted human support. These conditions are expected to influence whether voice-based information becomes a useful component of agricultural decision-making rather than merely another communication channel.

3. Review of Literature

3.1 Mobile Agricultural Extension and the Importance of Accessible Information

Aker's review of ICT-enabled agricultural extension emphasizes that mobile technologies can reduce communication costs and provide information more rapidly than many conventional extension channels. At the same time, the review cautions that agricultural information generates value only when it is timely, relevant, credible, and linked with farmers' practical production decisions. Nakasone, Torero, and Minten similarly conclude that mobile communication has transformed agricultural information environments, while evidence concerning micro-level impacts remains heterogeneous across services and settings. These findings caution against equating message delivery with successful extension.

Fafchamps and Minten's randomized evaluation of SMS-based agricultural information found some influence on particular farmer decisions but no statistically significant average improvements across several major production and marketing outcomes. This finding is especially relevant to low-literacy extension because it suggests that information provision alone may not be sufficient. Farmers must understand the content, trust its source, recognize its relevance, and possess the resources needed to implement the recommendation.

Fabregas, Kremer, and Schilbach's synthesis of digital agricultural advisory research nevertheless provides evidence that digital information can influence farm practices. Their review reported positive average effects on adoption of recommended inputs and smaller average improvements in agricultural yields across evaluated interventions. The variation across programs reinforces the importance of delivery design and suggests that future digital agricultural extension should focus less on whether information is delivered digitally and more on which combinations of content, interface, timing, and support enable farmers to use it.

3.2 Voice Interfaces, Low-Literacy Accessibility, and Interactive Advisory

Research on low-literacy interface design provides a strong foundation for voice-based agricultural systems. Medhi, Sagar, and Toyama found that interfaces combining meaningful graphics, voice feedback, and simplified interaction can substantially improve usability for users who cannot comfortably depend on text. They also emphasized the importance of consistent assistance and interface design grounded in the users' actual communication environment. These principles apply directly to agricultural advisory because an oral information service can avoid several literacy barriers while retaining access through basic telephone technology.

Patel and colleagues' Avaaj Otalo study provides agricultural evidence for interactive voice design. The system allowed farmers to listen to agricultural announcements, browse expert responses, ask questions, and participate in a voice-based community. Farmers particularly valued the question-and-answer forum, suggesting that agricultural communication benefits from interaction rather than only one-directional information transmission. The system also demonstrated that voice technology can support peer knowledge exchange, thereby combining formal agricultural expertise with farmers' experiential learning.

Cole and Fernando subsequently evaluated a voice-based agricultural advisory system over an extended period and found considerable demand and trust in the service, alongside changes in information seeking and recommended input adoption. Their results did not establish systematic gains across all productivity and profitability outcomes, however, which highlights the distinction between communication effectiveness and agricultural impact. Fernando's related research further indicates that digital extension need not eliminate farmer-to-farmer information exchange and can instead alter how information circulates through rural peer networks. Voice platforms can therefore function as both advisory systems and nodes within wider social learning networks.

3.3 Language, Timing, Trust, and the Remaining Inclusion Gap

Large-scale mobile advisory programs demonstrate that reach does not guarantee equal use. Kansiime and colleagues' evaluation of Direct2Farm found that the service reached large numbers of farmers and influenced uptake of agricultural practices, yet participation was weaker among some groups, including small-scale farmers, women, and older users. The study identified literacy, language, phone access, and control over devices as possible contributors to this digital divide. The same evaluation reported incomplete listening to many voice messages, illustrating that voice delivery can fail when farmers are contacted at unsuitable times or encounter poor reception.

Voice systems must therefore give farmers greater control over when and how information is accessed. Push calls are useful for urgent alerts, but a missed call should not mean permanent loss of the information. A complementary pull mechanism can allow farmers to call back, hear recent messages, repeat important sections, or request specialist advice. Local-language delivery should similarly go beyond literal translation. Agricultural terminology, pronunciation, dialect, crop names, and measurement units should reflect the communication practices of the intended farming population.

A further gap concerns personalization. Agricultural advice is rarely universally applicable. Crop stage, variety, location, soil characteristics, weather, irrigation access, livestock type, and previous management actions can determine whether a recommendation is appropriate. Effective voice services should therefore progressively move from generic broadcasting toward contextualized information while remaining transparent about the limitations of automated recommendations. The strongest model is likely to combine digital scale with human extension expertise rather than attempting to remove people entirely from advisory delivery.

4. Research Methodology

4.1 Research Design and Evidence Base

The study adopts a conceptual–methodological design based on structured synthesis of research concerning mobile agricultural extension, low-literacy interface design, interactive voice systems, farmer information behavior, and digital agricultural advice. The purpose is to develop an inclusive advisory framework rather than to estimate the impact of an existing commercial or governmental service.

The unit of analysis is the voice-advisory interaction, defined as an instance through which a farmer receives, retrieves, navigates, requests, repeats, or clarifies agricultural information through spoken mobile communication. The analysis concentrates on the relationship among technical accessibility, message comprehension, contextual relevance, trust, and capacity for agricultural action.

4.2 Voice-Advisory Accessibility Framework

Five dimensions were developed from recurring findings in the literature and from design characteristics observed in agricultural voice systems. These dimensions are intended to support both service design and subsequent evaluation.

Table 1: Accessibility Framework for Voice-Based Agricultural Advisory Services

Design Dimension	Common Access Barrier	Recommended Voice-System Feature	Expected Extension Benefit
Spoken-language relevance	Written or standardized terminology is difficult to interpret	Local language, familiar terminology, regionally appropriate pronunciation	Greater comprehension and trust

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Design Dimension	Common Access Barrier	Recommended Voice-System Feature	Expected Extension Benefit
Cognitive simplicity	Long audio messages exceed working-memory capacity	Short sequential messages with one principal recommendation	Improved recall
Interaction and replay	One-way message is missed or partly understood	Replay, pause, call-back, and simple keypad navigation	Greater user control
Contextual personalization	Generic advice may not match farm conditions	Crop-, location-, season-, and weather-specific targeting	Higher practical relevance
Human escalation	Automated advice cannot resolve complex farm problems	Expert callback or extension-worker referral	Safer interpretation and stronger credibility

The framework deliberately includes human escalation because automated agricultural communication has limits. A farmer describing an unfamiliar crop symptom, complex livestock illness, unusual weather-related damage, or pesticide issue may require diagnostic interaction that cannot responsibly be resolved through a generic prerecorded message.

4.3 Scenario-Based Accessibility Analysis

A scenario model was created to compare five advisory configurations: text-only SMS, generic voice broadcast, local-language voice advisory, interactive IVR with replay, and personalized voice advisory with expert callback. A simulated Advisory Accessibility Index (AAI) was used to represent the combined contribution of comprehension, control, contextual relevance, trust, and actionability.

Conceptually:

[AAI=\frac{L+C+I+P+T}{5}]

where:

(L) = spoken-language accessibility, (C) = cognitive clarity, (I) = interaction and replay capability, (P) = contextual personalization, and (T) = trusted support availability.

Each component is conceptualized on a standardized scale. The resulting index is not a validated psychometric or extension-performance instrument. All values used below are simulated solely to illustrate theoretical differences among advisory models. Actual validation would require farmer-level usability testing, comprehension measures, service analytics, behavioral outcomes, and appropriate sampling procedures.

5. Analysis

5.1 Accessibility Improves When Farmers Control the Information Encounter

The conceptual analysis indicates that one of the most important differences between conventional broadcast communication and an effective voice service is user control. A text message remains available on the phone for later reading, whereas an automated voice call can disappear once the call ends. This creates a paradox: voice communication may reduce literacy barriers while increasing dependence on correct call timing.

Interactive design addresses this limitation. Farmers should be able to retrieve recent advisories, replay the complete message or a particular section, and request additional explanation. Menu structures should remain shallow because long hierarchies increase the probability that users become disoriented. Patel and colleagues' field evidence showing successful use of simple menu-based navigation supports the value of reducing interaction complexity.

The same principle applies to message duration. Advisory content should be divided into manageable units rather than presenting several agronomic decisions in one call. A pest-management message, for example, can first identify the target problem, then describe the recommended response, and finally provide a separate option for dosage, safety, or further clarification.

5.2 Simulated Comparison of Agricultural Advisory Delivery Models

The analytical simulation compares the accessibility of increasingly voice-centered and interactive advisory designs.

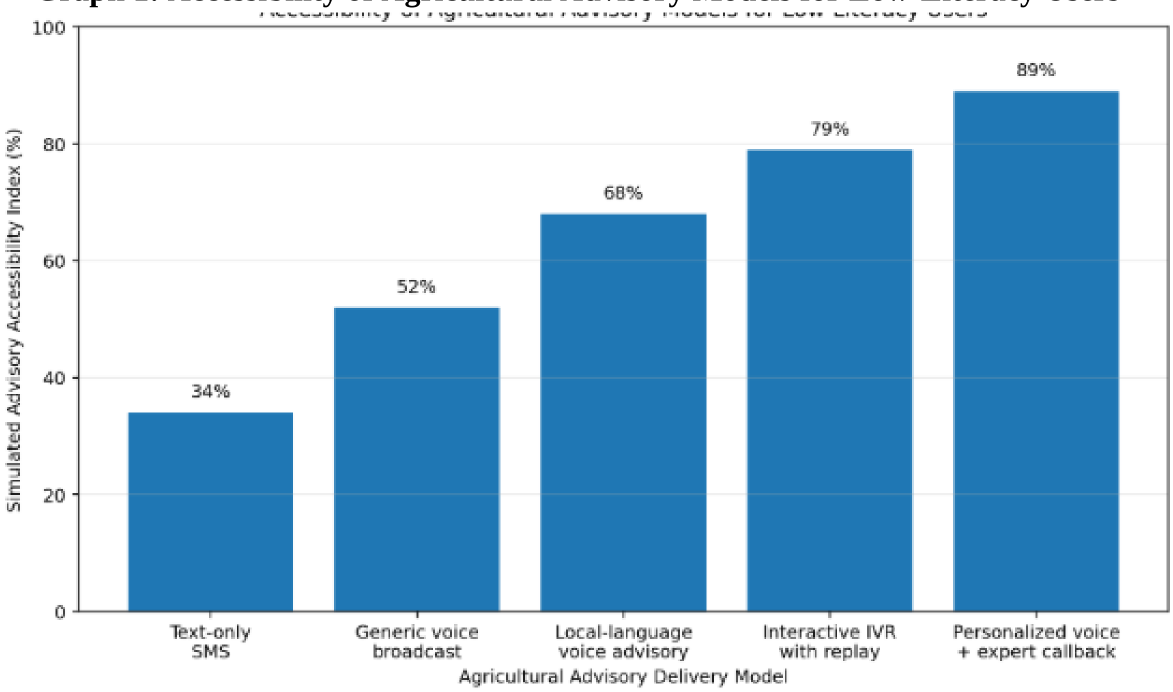
Table 2: Simulated Advisory Accessibility for Low-Literacy Users

Advisory Delivery Model	Simulated Accessibility Index (%)	Principal Limitation or Strength
Text-only SMS	34	Strong dependence on reading proficiency
Generic voice broadcast	52	Reduces reading burden but remains one-way and time dependent
Local-language voice advisory	68	Improves linguistic comprehension and familiarity
Interactive IVR with replay	79	Adds user control, repetition, and menu-based information access
Personalized voice + expert callback	89	Combines accessibility, contextual relevance, and human clarification

Note: All values are illustrative scenario scores. They do not represent observations from farmers, extension agencies, or commercial advisory platforms.

The simulation suggests that simply replacing text with a voice recording produces an accessibility improvement but leaves important barriers unresolved. Local-language delivery creates a stronger conceptual improvement because farmers receive information through familiar linguistic structures. Interactive IVR adds replay and user control, while the personalized model achieves the highest simulated accessibility because it combines digital convenience with contextual targeting and access to human expertise.

Graph 1: Accessibility of Agricultural Advisory Models for Low-Literacy Users



The graph represents conceptual differences rather than measured service performance. Its central message is that voice alone is not the endpoint of accessibility. The strongest advisory architecture integrates understandable speech, user-controlled interaction, locally relevant content, personalization, and escalation when automated information is insufficient.

5.3 From Accessible Voice Messages to Agricultural Decisions

Accessibility becomes valuable only when the advice contributes to appropriate decision-making. Farmers may understand a recommendation yet remain unable to implement it because an input is unavailable, unaffordable, incompatible with local conditions, or inconsistent with other trusted advice. Advisory evaluation should therefore separate message comprehension, recommendation acceptance, practice adoption, and eventual farm outcomes.

This distinction is supported by empirical agricultural ICT research. Cole and Fernando found that a voice advisory service influenced information use and recommended agricultural input adoption but did not produce systematic improvements across all yield and profitability measures. Fafchamps and Minten likewise found limited average impacts for several outcomes from mobile information provision.

Digital extension should consequently avoid interpreting high call completion or listening rates as proof of agricultural impact.

A responsible evaluation system should monitor at least four stages: whether the farmer received or retrieved the information, whether the recommendation was understood, whether it influenced a decision, and whether the resulting practice was technically appropriate. This staged approach provides more useful evidence than counting messages sent.

6. Discussion

6.1 Voice Should Be Designed as a Communication Environment, Not an Audio File

The first major implication is that audio delivery should not be treated as a simple conversion of text into speech. Low-literacy accessibility requires redesigning information around listening behavior. Long technical sentences that function adequately in written extension material may be difficult to retain when heard once through a mobile phone under field conditions.

Medhi, Sagar, and Toyama's interface research demonstrates the broader importance of designing around actual low-literacy user practices rather than modifying conventional interfaces superficially. Applied to agriculture, this means that audio advisories should use concise structures, familiar words, deliberate repetition, consistent menu patterns, and predictable options for help.

Voice systems should also acknowledge that agricultural users may listen in noisy environments, while working outdoors, traveling, or sharing phones with family members. Audio quality, message length, call timing, and the ability to repeat content are therefore substantive accessibility variables rather than minor technical details.

6.2 Personalization and Trust Are Central to Agricultural Usefulness

Agricultural information is valuable when farmers believe both the content and the source are relevant to their circumstances. A generic recommendation concerning irrigation or pesticide application can be inappropriate when local weather, crop stage, soil conditions, or pest pressure differ. Personalization should therefore use only the information necessary to improve agronomic relevance and should avoid creating unnecessary data burdens.

Evidence from the Direct2Farm program shows that messages can be targeted according to characteristics including location, language, crop, livestock, and farming practices. This type of targeting can reduce irrelevant messaging and increase the probability that farmers consider an advisory worth listening to. However, personalization should remain transparent so that farmers understand why they received particular recommendations and can correct outdated farm-profile information.

Trust is equally important. Voice advisory should identify the responsible agricultural institution or expert source clearly. Where recommendations involve substantial financial, safety, or crop-loss implications, users should have access to an extension worker, agronomist, or appropriate specialist. Voice technology is most defensible as an extension multiplier rather than as an unaccountable replacement for professional agricultural judgment.

6.3 Inclusion Requires Attention to Gender, Device Access, and Service Timing

A voice interface can remove a literacy barrier while leaving other inequalities unchanged. Household ownership of a mobile phone does not necessarily mean that every farmer can access it independently. Women, older farmers, hired workers, and economically marginalized users may have different control over devices, airtime, charging, private listening space, and preferred call times. Kansiime and colleagues' findings regarding differential participation in mobile advisory services reinforce the importance of these social conditions.

Inclusive service design should therefore measure actual user access rather than household-level phone ownership alone. Registration systems can record preferred language and calling periods, while missed-message retrieval can reduce the consequences of temporary phone unavailability. Toll-free access is especially important for farmers who may otherwise avoid repeated information retrieval because of call charges.

Voice-based agricultural extension should ultimately be evaluated by who can use it reliably, not simply by how many telephone numbers appear in a database. A service reaching a large nominal population but systematically excluding farmers with limited device control, unstable networks, unfamiliar languages, or inconvenient work schedules cannot be considered fully accessible.

7. Conclusion

Voice-based agricultural advisory services offer a significant opportunity to extend digital agricultural communication to users for whom text-intensive services are inconvenient or inaccessible. Their principal advantage lies in the use of familiar spoken communication through widely available mobile devices, allowing agricultural information to be delivered without requiring continuous dependence on written interfaces or smartphones.

The framework developed in this study identifies spoken-language relevance, cognitive simplicity, interaction and replay, contextual personalization, and trusted human escalation as five core dimensions of inclusive voice-based extension. These dimensions shift attention from technological delivery toward communication quality. A service should not be judged solely by its ability to make automated calls; it should be evaluated according to whether farmers can understand, retrieve, question, contextualize, and responsibly use the information.

The scenario analysis indicates theoretically that accessibility improves progressively from text-only communication toward local-language interactive and personalized voice services. These values are simulated and should not be interpreted as empirical estimates. Future research should validate the framework through field experiments involving low-literacy users, comprehension testing, call-log analysis, gender-disaggregated access measures, farmer interviews, extension-worker assessments, and observation of actual agricultural decisions.

The broader implication is that digital agricultural extension should combine technological scale with the strengths of human agricultural communication. Voice systems can efficiently disseminate routine and time-sensitive information, while interactive functionality and expert support can address uncertainty and complex farm conditions. When designed around farmers' linguistic practices, working environments, social circumstances, and decision needs, voice-based agricultural advisory can become an inclusive complement to conventional extension rather than simply another digital information channel.

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