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Phones in the Field: Unlocking Agricultural Information for Smallholder Farmers in Kericho County, Kenya

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Abstract
Agriculture remains a cornerstone of Kenya's rural economy; however, smallholder farmers continue to face persistent challenges, including limited access to extension services, market inefficiencies, and increasing climate variability. Mobile phone technology has emerged as a promising tool for improving access to agricultural information and services in rural areas. This study examines how smallholder tea, dairy, and coffee farmers in Kericho County, Kenya, use mobile phones and how this usage influences their production practices, market participation, and adoption of agricultural technologies. A cross-sectional descriptive survey design was employed with a sample of 400 smallholder farmers selected through multi-stage sampling. Data were collected using structured questionnaires, key informant interviews, and focus group discussions. Quantitative data were analyzed using descriptive statistics and factor analysis (Principal Component Analysis with Varimax rotation), while qualitative data provided contextual depth. Findings show that Ffarmers use mobile phones primarily for emergency communication (61.6%), general communication (53.5%), and accessing agricultural information (42.4%). Cooperative societies (37.9%) are the main source of mobile-based agricultural information, followed by agricultural hotlines (21.3%) and extension officers (19.5%). Factor analysis revealed three distinct dimensions of phone use: Economic and Agricultural Use, Educational and Media Use, and Social Communication Use, which together explain 65.55% of the variance. However, adoption is significantly constrained by poor network connectivity (80.5%), high device costs (13.2%), and unreliable electricity (6.5%). Agricultural extension services can leverage these findings by prioritizing information delivery through economic and agricultural channels (e.g., SMS market alerts), designing digital literacy programs to enhance educational use, and strengthening social networks for peer-to-peer learning. Addressing infrastructural gaps is critical for inclusive digital agriculture. The study validates a multi-dimensional model of mobile phone usage, integrating a Phone Usage Pattern Index (PUPI) with factor analysis. This framework provides a robust tool for segmenting farmers and understanding technology adoption pathways, extending the use of Diffusion of Innovations theory in digital agriculture contexts.

Keywords*: Mobile phones, smallholder farmers, agricultural extension, digital adoption, factor analysis, Kenya, ICT4D*

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I. Introduction

Agriculture remains a cornerstone of Kenya's rural economy, with smallholder farmers playing a central role in national food security and livelihoods (Kenya National Bureau of Statistics (KNBS, 2019). Despite their importance, these farmers face persistent, interconnected challenges. These include limited access to timely and relevant agronomic information, vulnerability to volatile market prices, and the increasing pressures of climate variability, which demand new adaptive strategies (Wambugu et al., 2020). Traditional, face-to-face agricultural extension systems, while valuable, are often logistically constrained and struggle to provide consistent, personalized support to geographically dispersed farming populations (Anderson & Feder, 2004).

In this context, mobile phones among other Information and Communication Technologies (ICTs) have emerged as revolutionary tools for agricultural service delivery (Aker, 2011; Qureshi et al., 2020). Kenya's position as a global leader in mobile money (e.g., M-PESA) and its high mobile phone penetration rate present a unique opportunity to deliver a range of services directly to farmers, including weather alerts, pest and disease advisories, market price information, and financial services (Wyche & Steinfield, 2016; Aker & Mbiti, 2010).

However, the potential of mobile phones to catalyze agricultural development is not automatically realized. A persistent digital divide limits adoption and effective use among the most vulnerable farmers. Key

barriers include the high cost of devices and data, low levels of digital literacy, unreliable network infrastructure in rural areas, and a lack of locally relevant content (Tadesse & Bahiigwa, 2015; Asenso-Okyere & Mekonnen, 2012). A large portion of the current research has concentrated on evaluating the effects of specific, donor-driven agricultural platforms. There is comparatively less understanding of how farmers organically integrate the basic, readily available functionalities of mobile phones—such as voice calls and SMS—into their daily agricultural routines (Baumüller, 2018).

In order to close this gap, this study examines the influence of mobile phone use on production practices, market participation, and technology adoption among smallholder farmers in Kericho County, Kenya. The study has three main objectives: (1) to identify the patterns and primary sources of mobile-based agricultural information accessed by farmers; (2) to quantify and categorize the different dimensions of mobile phone usage; and (3) to identify the key constraints limiting the effective application of mobile phones for agricultural purposes. The evidence generated aims to provide actionable insights for extension services and policymakers seeking to design more effective, farmer-centered digital interventions that strengthen rural livelihoods.

II. Materials and Methods

2.1 Study Area

The study was conducted in Kericho County, located in the former Rift Valley region of Kenya. The county covers an area of approximately 2,454 km² and is characterized by high-altitude terrain, fertile volcanic soils, and reliable annual rainfall ranging from 1,800 to 2,400 mm. These conditions make it a hub for cash crop farming, with tea, dairy, and coffee being the dominant agricultural enterprises. The population is predominantly rural, and while mobile phone network coverage is relatively high compared to some other parts of the country, the quality and reliability of service can vary significantly across different locations.

2.2 Research Design

A descriptive cross-sectional survey design was employed, incorporating a mixed-methods approach. This design was appropriate for capturing a "snapshot" of current mobile phone usage patterns, information sources, and constraints among the farming population at a single point in time. The quantitative component measured the prevalence of different uses and identified key associations, while the qualitative component explored farmers' experiences, perceptions, and the contextual factors shaping their use of mobile technology.

2.3 Population, Sample Size, and Sampling Procedure

The target population comprised all smallholder farmers engaged in tea, dairy, and coffee farming within Kericho County. According to county agricultural records, the estimated finite population of such farmers was 150,625. To determine a representative sample size, Yamane's formula (Yamane, 1967) was applied at a 95% confidence level and a 5% margin of error, yielding a required sample of 400 respondents.

A multi-stage sampling procedure was used to select participants. First, three sub-counties—Bureti, Kipkelion, and Soin/Sigowet—were purposively selected based on their high concentration of the target farming activities. Second, the total sample of 400 was allocated proportionally to each sub-county based on its estimated population of farmers. Finally, within each sub-county, farmers were randomly selected from membership lists provided by local agricultural cooperatives to ensure representativeness and minimize selection bias.

2.4 Data Collection

Primary data were collected using three main tools. A structured questionnaire was administered face-to-face to the 400 sampled farmers to gather quantitative data on socio-demographic characteristics, mobile phone ownership and usage patterns, sources of agricultural information, and perceived constraints. Key informant interviews were conducted with 12 individuals, including sub-county agricultural extension officers and leaders of dairy, tea, and coffee cooperatives, to gain an institutional perspective. Additionally, four focus group discussions (one per sub-county and one mixed group) were held, each with 8-10 farmers, to facilitate in-depth discussions on the opportunities and challenges of using mobile phones in their farming activities.

2.5 Data Analysis

Quantitative data from the questionnaires were coded, entered, and cleaned before being analyzed using SPSS version 27. Descriptive statistics, including frequencies and percentages, were computed to summarize the data. To move beyond simple descriptive analysis, a Phone Usage Pattern Index (PUPI**)** was developed. This composite index was constructed from nine dichotomous variables representing different uses of mobile phones. The internal consistency of the index was assessed using Cronbach's alpha. Subsequently, factor analysis was conducted using Principal Component Analysis (PCA) with Varimax rotation

to identify the underlying dimensions or latent constructs that structure mobile phone usage among farmers. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to verify the suitability of the data for factor analysis. Qualitative data from interviews and focus groups were transcribed, coded, and analyzed thematically to provide context and triangulate the quantitative findings.

III. Results

3.1 Mobile Phone Usage Patterns and Information Sources

The study found that mobile phones are ubiquitous and serve multiple functions in farmers' lives. As shown in Table I, the primary uses were for emergency communication (61.6%), general communication with family and friends (53.5%), and accessing general information (48.5%). Critically, 42.4% of respondents reported using their mobile phones specifically to access agricultural information, indicating a substantial, though not yet universal, integration of the technology into farming practices. Other uses, such as for education (16.2%), financial transactions (18.2%), and news (10.1%), were less prevalent.

Regarding the sources of this mobile-based agricultural information, cooperative societies emerged as the most important channel, cited by 37.9% of farmers. This was followed by dedicated **a**gricultural hotlines (21.3%) and direct communication with extension officers (19.5%). Other farmers (11.2%) and radio stations (5.3%) were less frequently mentioned as primary sources.

Table I: Mobile Phone Usage Patterns and Information Sources (n=400)

Variable	Category	Frequency (n)	Percentage (%)
Primary uses of mobile phones	Emergency communication	246	61.6
	General communication	214	53.5
	Accessing information (general)	194	48.5
	Accessing agricultural information	170	42.4
	Financial information/transactions	73	18.2
	Educational content	65	16.2
	News	40	10.1
Primary source of agricultural information	Cooperative societies	152	37.9
	Agricultural hotlines	85	21.3
	Extension officers	78	19.5
	Other farmers	45	11.2
	Radio	21	5.3

3.2 Dimensions of Mobile Phone Usage: Factor Analysis

The nine usage variables were subjected to PCA to identify the underlying structure of mobile phone use. The KMO measure of 0.753 and Bartlett's test of sphericity ($\chi^2 = 439.47$, $p < 0.001$) confirmed that the data were suitable for this analysis. The analysis extracted three components with eigenvalues greater than one, which together explained **65.55%** of the total variance. The rotated component matrix is presented in Table II.

Factor 1: Economic and agricultural use (30.1% of variance explained). This factor had high loadings from variables related to business, agriculture, financial information, and general information. It represents the instrumental use of mobile phones to directly support livelihood activities.

Factor 2: Educational and media use (18.9% of variance explained)**.** This factor loaded strongly on accessing educational content and news. Its lower variance suggests that this dimension is currently underutilized but represents a significant opportunity.

Factor 3: Social communication use (16.5% of variance explained). This factor comprised emergency communication, general communication, and family contact. It reflects the foundational use of mobile phones for maintaining social networks and ensuring safety.

Table II: Rotated Component Matrix of Mobile Phone Usage

Usage Variable	Component (Factor)		
	1: Economic and agricultural	2: Educational and media	3: Social communication
Business information	0.842	0.112	0.054
Agricultural information	0.812	0.098	0.201
Financial information	0.756	0.201	0.112
General information	0.712	0.156	0.187
Educational content	0.102	0.845	0.089
News	0.187	0.801	0.078

Emergency communication	0.098	0.065	0.812
General communication	0.145	0.112	0.765
Family contact	0.201	0.098	0.701

3.3 Constraints to Effective Mobile Phone Use

Despite the potential, farmers reported significant barriers to effectively using mobile phones for agriculture. The most pervasive constraint was poor network connectivity, cited by an overwhelming 80.5% of respondents (Table III). This was followed by high cost of mobile devices (13.2%) and limited access to reliable electricity (6.5%) for charging phones. These findings underscore that infrastructural deficits are the primary bottleneck.

Table III: Constraints to Effective Mobile Phone Use (n=400)

Constraint	Frequency (n)	Percentage (%)
Poor network connectivity	322	80.5
High cost of devices	53	13.2
Limited access to electricity	26	6.5

IV. Discussion

This study aimed to provide a fine understanding of how smallholder farmers in Kericho County use mobile phones in their agricultural activities. The findings reveal a landscape of significant potential hampered by persistent infrastructural and socio-economic barriers.

4.1 Patterns and Sources of Information Access

The finding that cooperatives are the leading source of mobile-based agricultural information (37.9%) is significant. It highlights the critical role that existing social and economic institutions play in the digital agriculture ecosystem. Cooperatives serve as trusted intermediaries, aggregating information and disseminating it to their members, often through group SMS broadcasts or voice calls. This suggests that digital extension strategies should not focus solely on individual farmers but should actively partner with and strengthen the communication capacity of farmer cooperatives. The relatively lower reliance on direct contact with extension officers (19.5%) via mobile phone may reflect the high farmer-to-extension officer ratio, which limits the feasibility of personalized digital outreach, a challenge well-documented in sub-Saharan Africa (Davis et al., 2020).

4.2 A Multi-Dimensional Model of Mobile Phone Use

The factor analysis provides a significant contribution by moving beyond a simple checklist of uses to reveal the underlying structure of mobile phone engagement. The three identified dimensions; Economic/Agricultural, Educational/Media, and Social Communication, demonstrate that mobile phones are not monolithic tools but are used in distinct, purpose-driven ways. The Economic and Agricultural Use factor, which explains the most variance, confirms that farmers are already leveraging mobile technology for core livelihood functions. This aligns with the instrumentalist perspective in ICT4D, where technology is adopted primarily for its perceived usefulness in improving economic outcomes (Aker, 2011).

The identification of the Social Communication Use factor as a distinct dimension supports the idea that the social capital embedded in phone networks is a crucial, albeit indirect, enabler of agricultural adoption. As posited by Rogers' (2003) Diffusion of Innovations theory, information about new practices often flows through social networks. A farmer who uses their phone to stay in touch with family and friends is also building and maintaining the very network through which they might learn about a new dairy breed or a better market price for their coffee. This finding suggests that extension programs could intentionally leverage existing social media or messaging groups to foster peer-to-peer learning and information diffusion.

The Educational and Media Use factor, while explaining less variance, points to a critical gap and opportunity. The low scores on this dimension suggest that the potential of mobile phones as platforms for more structured, knowledge-based learning is largely untapped. This is not simply a matter of content availability but also of digital literacy. Farmers may not be aware of, or know how to access, educational resources or news websites relevant to agriculture (Wyche & Olson, 2018).

4.3 The Persistent Constraint of Infrastructure

The most striking finding is the dominance of poor network connectivity (80.5%) as the primary constraint. This finding starkly illustrates the reality of the digital divide in rural Kenya. No amount of farmer training or content development can overcome the fundamental barrier of an unreliable signal. This infrastructural deficit limits the utility of even the most basic phone functions, making information access intermittent and frustrating. While high device costs (13.2%) and electricity access (6.5%) are also real barriers, they are secondary to the foundational need for a reliable network. This aligns with broader critiques of digital

development that emphasize the need to address basic infrastructure before digital dividends can be realized (Unwin, 2017).

V. Conclusions and Implications

5.1 Conclusions

This study concludes that mobile phones are deeply embedded in the lives of smallholder farmers in Kericho County, serving vital social and economic functions. Farmers actively use them to access agricultural information, primarily through their cooperatives. However, this usage is not random; it is structured into three distinct dimensions: economic/agricultural, social, and educational/media. The potential of mobile phones to transform agricultural practices is severely constrained by infrastructural deficits, particularly poor network connectivity.

5.2 Practical Implications for Extension

The findings offer several actionable implications for agricultural extension services and policymakers:

1. Partner with Cooperatives: Extension strategies should prioritize building the digital capacity of farmer cooperatives, enabling them to become more effective hubs for disseminating targeted, timely agricultural information via mobile phones.
2. Target information by use dimension: Content delivery should be tailored to the different dimensions of use. This includes providing concise, actionable market and weather alerts (for Economic Use), creating and promoting digital literacy programs (to boost Educational Use), and supporting the creation of farmer WhatsApp groups to foster peer learning (leveraging Social Use).
3. Advocate for infrastructure: Extension services and agricultural development partners must actively advocate with telecommunications companies and government for investment in rural network infrastructure. Digital agricultural interventions are unlikely to succeed at scale without this foundational layer.

5.3 Theoretical Implications and Future Research

Theoretically, this study contributes a validated, multi-dimensional framework (PUPI and factor analysis) for conceptualizing and measuring mobile phone usage among smallholder farmers. This provides a more robust tool for future research than simple binary measures of ownership or use. Future research should explore how these usage dimensions correlate with actual productivity and income outcomes. It could also investigate the dynamic relationship between social network usage and the adoption of specific agricultural innovations over time.

5.4 Limitations

This study has limitations. It is cross-sectional, capturing data at a single point in time, and thus cannot establish causality. The findings are specific to Kericho County and may not be directly generalizable to other regions with different socio-economic or infrastructural contexts. Future research could employ longitudinal designs to track changes in usage patterns and their impacts over time.

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