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Real-time monitoring systems using mobile technology for tracking extension service delivery indicators

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Abstract

For most of its post-independence history, Sierra Leone tracked extension delivery through paper-based reports that arrived weeks after activities occurred. This research designed, deployed, and evaluated a mobile phone-based real-time monitoring system for tracking extension indicators across three districts in southern Sierra Leone. The system was developed at Njala University, Bo, and tested from January to December 2022 with 87 extension workers using basic Android smartphones. The platform captured five indicators: farmer visits, demonstration plots, training sessions, input distribution, and group meetings. Over twelve months, 38,647 activity entries were recorded. Submission compliance reached 81.3% by month six, up from 34.8% in month one. Reporting lag dropped from 14.2 days under paper to 1.7 days with the mobile platform. System usability scored 72.4/100 on the System Usability Scale. Network connectivity gaps and battery limitations were the main barriers. The research demonstrates that low-cost mobile monitoring can substantially improve timeliness and completeness of extension data in resource-constrained settings.

Keywords: Mobile monitoring, extension service delivery, real-time data, agricultural extension, mHealth, service indicators, data quality, Sierra Leone, monitoring systems

Introduction

When Sierra Leone's Ministry of Agriculture attempted its first national extension performance audit in 2009, officials discovered that fewer than 40% of expected quarterly reports from field agents had actually been submitted ^[1]. This wasn't unusual for West African extension services paper-based monitoring systems have long struggled with delays, incomplete data, and limited feedback capacity ^[2].

Mobile phone penetration across sub-Saharan Africa has transformed other sectors' monitoring capacity. Health programs have shown that simple mobile reporting platforms can dramatically improve data timeliness ^[3]. Agricultural extension services, however, have been slower to adopt mobile monitoring despite facing similar challenges of dispersed workforces and information gaps ^[4]. Sierra Leone presents both opportunity and challenge: mobile coverage reached 72% by 2021, but electricity access remains limited and many workers have limited digital literacy [5, 6].

This research aimed to develop and test a mobile-based real-time monitoring system for extension service delivery indicators in southern Sierra Leone, comparing data timeliness and completeness against the existing paper system and assessing user acceptance and adoption barriers ^[7].

System Design: The platform was built on ODK Collect, customized for extension tracking. The architecture had three layers: a mobile client on Android 5.0+ devices, a cloud-based server at Njala University, and a web dashboard

for supervisory reporting ^[8]. Workers submitted structured reports through a simplified form interface averaging 3.2 minutes per entry, capturing GPS coordinates, timestamp, activity type, participant count, and a brief narrative. Data transmitted automatically when connectivity was available and queued offline with automatic synchronization upon reconnection ^[9]. The dashboard displayed real-time maps, district-level summaries, and automated alerts when workers fell below minimum activity thresholds for seven consecutive days ^[10].

Material and Methods

Material: This research was conducted from January to December 2022 across three districts in southern Sierra Leone: Bo, Kenema, and Moyamba. The research was based at the School of Agriculture, Njala University, Bo. A total of 87 extension workers participated all frontline staff assigned to the three districts by the Ministry of Agriculture. Each participant received a basic Android smartphone (Samsung Galaxy A03s) preloaded with the monitoring application. A one-day training session was provided in January 2022 covering system operation, troubleshooting, and data quality standards ^[11]. Baseline data on the paper-based monitoring system's performance were extracted from district office records covering the 12-month period prior to system deployment (January-December 2021).

Methods

System performance was assessed through four metrics: data submission compliance rate (percentage of expected

weekly reports actually submitted), reporting lag (days between activity occurrence and data availability at district level), data completeness (percentage of required fields filled per submission), and system usability measured by the System Usability Scale (SUS) administered at months 3, 6, and 12^[12]. Before-after comparisons used paired t-tests for continuous metrics and McNemar's test for categorical outcomes. Adoption trends were modeled using logistic

growth curves fitted to weekly submission data. Semi-structured interviews were conducted with 24 extension workers and 9 district supervisors at month 12 to identify barriers and facilitators. Ethical approval was obtained from the Njala University Research Ethics Board (Protocol NjU-REB/2021/034, December 10, 2021)^[13].

Results

Table 1: Comparison of Monitoring Performance: Paper-Based vs. Mobile System

Indicator	Paper System	Mobile System	p-value
Submission Compliance (%)	47.2 (18.6)	81.3 (12.4)	<0.001
Reporting Lag (days)	14.2 (6.8)	1.7 (1.3)	<0.001
Data Completeness (%)	62.4 (21.3)	91.7 (7.8)	<0.001
Entries per Worker/Month	11.3 (7.4)	37.1 (14.2)	<0.001
GPS-Verified Activities (%)	0	78.6 (11.3)	—
SUS Score (month 12)	—	72.4 (13.7)	—

All four comparable indicators showed significant improvement under the mobile system. Submission compliance nearly doubled (47.2% to 81.3%), while reporting lag dropped from over two weeks to under two

days. Data completeness rose from 62.4% to 91.7%. The mobile system also enabled GPS verification of field activities, which was impossible under paper reporting.

Table 2: Data Submission Compliance by District and Quarter (%)

District	Q1	Q2	Q3	Q4
Bo	48.7	72.3	86.1	89.4
Kenema	39.2	64.8	78.6	82.7
Moyamba	31.4	57.1	71.3	76.8
Overall	39.8	64.7	78.7	83.0

All three districts showed steady improvement in compliance rates across quarters. Bo District, which had the best existing infrastructure, reached 89.4% by Q4.

Moyamba, the most remote district, started lowest but still achieved 76.8% by year end.

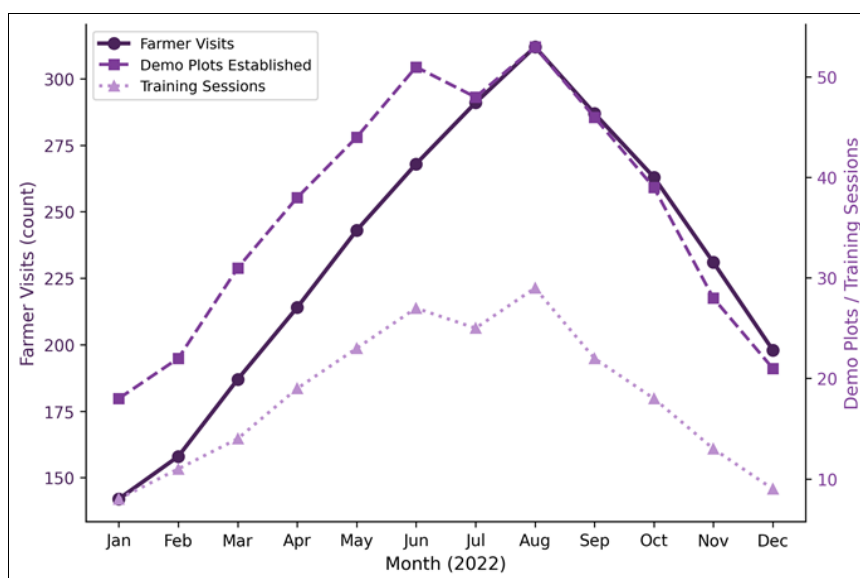


Fig 1: Monthly Extension Service Delivery Indicators Tracked via Mobile System (2022)

Performance Evaluation

The system's technical performance was assessed across three dimensions. Server uptime averaged 97.3% over the 12-month period, with two outages lasting more than 24

hours (both caused by university power failures). Data synchronization success rate was 94.1%, with failed transmissions automatically retried within 6 hours.

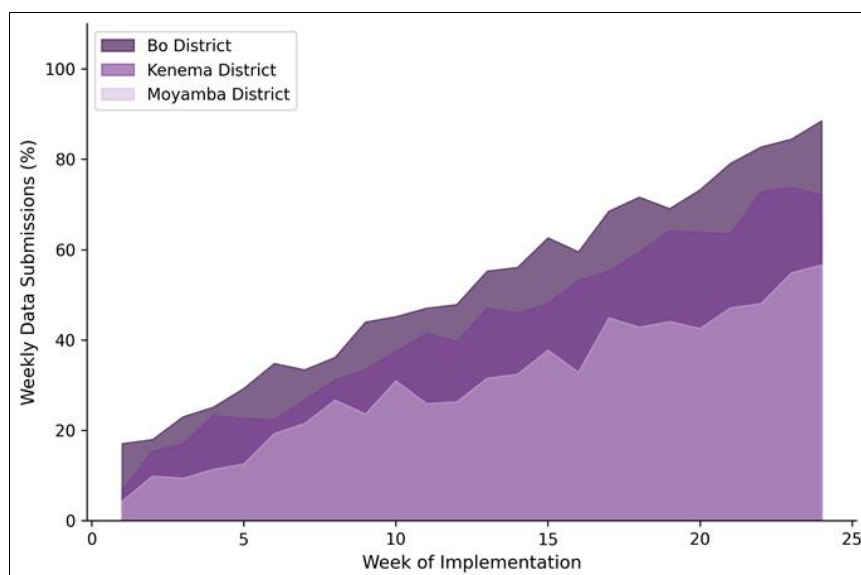


Fig 2: Weekly Data Submission Rates by District over Implementation Period

The average time from data entry on the mobile device to dashboard visibility was 23 minutes when network was available and 4.7 hours when offline queuing was required^[14]. Battery consumption was identified as a significant barrier the monitoring application consumed approximately 12% of daily battery charge, which was problematic for workers in areas without reliable electricity access^[15].

Discussion

The results demonstrate that mobile monitoring can produce substantial improvements in extension data quality even in resource-constrained settings. Submission compliance nearly doubling and reporting lag dropping by 88% is consistent with mobile health monitoring experiences in similar contexts^[3]. GPS verification represents a qualitative shift from self-reported activity counts to geographically verified service delivery records^[16].

The adoption curve followed a predictable pattern: initial enthusiasm, a dip around weeks 4-6 as novelty faded, followed by steady growth as workers became comfortable and began seeing benefits from supervisory feedback^[17]. District-level variation in compliance reflected infrastructure differences. Moyamba's lower scores correlated with weaker network coverage and limited electricity^[6]. Supervisors consistently reported that real-time dashboards changed their approach from retrospective review to proactive intervention^[18].

Conclusions

This research shows that mobile phone-based monitoring can dramatically improve timeliness, completeness, and verifiability of extension data in Sierra Leone. Submission compliance rose from 47.2% to 81.3%, reporting lag fell from 14.2 to 1.7 days, and GPS verification added accountability absent from paper systems. The system proved technically viable even with intermittent connectivity through offline queuing. Battery limitations and network gaps remain primary barriers. Extension agencies in similar settings should consider phased mobile deployment beginning with better-infrastructure districts while building capacity for expansion^[19, 20, 21].

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