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Effectiveness of mobile-based agricultural advisory services in improving crop management decisions

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Abstract
Could a smartphone app replace the village extension officer? This research tested the hypothesis that mobile-based advisory services improve crop management decisions by comparing three delivery channels—a custom smartphone app with push notifications, a weekly SMS bulletin, and no digital advisory (control)—among 360 arable farmers in Lower Saxony, Germany, over the 2023 growing season. Farmers were randomly assigned to groups (120 each). The app group made timelier fertiliser applications (4.3 days closer to the agronomic optimum), reduced unnecessary fungicide sprays by 22%, and achieved 6.8% higher wheat yield than the control. The SMS group showed intermediate improvements. Farmer satisfaction was highest for the app (7.8/10) and lowest for SMS (6.2/10), mainly because the app allowed image-based pest identification. Adoption—defined as continued use after 12 months—reached 74% for the app versus 48% for SMS. These findings suggest that interactive mobile platforms outperform passive text-based channels for agricultural advice, though connectivity gaps in rural Germany remain a barrier for roughly 18% of participating farms.

Keywords: C Mobile advisory, crop management, ICT in agriculture, extension services, technology adoption, smartphone app, precision farming, decision support, digital agriculture, farmer satisfaction.

Introduction

What if the most effective extension worker in Germany weren't a person at all, but a push notification? That hypothesis sounds extreme, but data from sub-Saharan Africa and South Asia show that mobile-delivered advice can match or beat face-to-face extension for simple management recommendations [1, 2]. In Germany, where farm sizes are larger and digital literacy is higher, the potential should be even greater—yet rigorous randomised comparisons are scarce [3].

Two types of mobile advisory coexist. SMS bulletins are cheap to send and work on any phone, but they're one-directional and limited to 160 characters per message [4]. Smartphone apps can push location-specific alerts, display images, and accept user queries, but they require data connectivity and a device that not every farmer owns [5]. Which channel actually changes management behaviour and, more importantly, improves yield and profitability?

This research aimed to (i) compare the effect of app-based versus SMS-based advisory on fertiliser timing, fungicide use, and wheat yield, (ii) measure farmer satisfaction and adoption over 12 months, and (iii) identify barriers to sustained use in a northern European arable context.

App Design and Advisory Content

The 'AgroPush' app was developed in-house using Flutter for cross-platform deployment. It delivered three advisory modules: (i) nitrogen timing based on crop growth stage and weather forecast, (ii) fungicide need based on disease-risk models (PROCULTURE algorithm adapted for Lower Saxony), and (iii) pest identification via a convolutional neural network trained on 12,000 annotated images. Push notifications were triggered by crop stage and local weather thresholds. The SMS service sent one generic advisory per week covering the same topics in text form. Content was drafted by university agronomists and reviewed by the local Landwirtschaftskammer [6, 7].

Theoretical Framework

The research drew on the Technology Acceptance Model (TAM), which posits that perceived usefulness and perceived ease of use predict technology adoption [8]. Farmer surveys at baseline, mid-season, and end-season captured TAM constructs alongside demographic variables (age, farm size, education, smartphone ownership). The research tested whether TAM constructs mediated the relationship between advisory channel and adoption behaviour.

Materials and Methods

Materials

The trial was conducted across 18 parishes in the Göttingen and Northeim districts of Lower Saxony (51°30′ N, 9°56′ E). A total of 360 wheat-growing farmers were recruited through the local Landwirtschaftskammer and randomly assigned (stratified by farm size) to three groups: app (n=120), SMS (n=120), and control (n=120). Farmers grew winter wheat (cv. 'Benchmark' or 'Chevignon') on loess-derived Luvisols. The research ran from October 2022 (sowing) to August 2023 (harvest) [9].

Methods

Fertiliser application dates were recorded by farmer logbooks and cross-checked with satellite imagery (Sentinel-2 NDVI anomalies). Fungicide use was documented as number of sprays and active ingredients applied. Yield was recorded by combine yield monitor (calibrated against weigh-bridge). Satisfaction was measured on a 1–10 Likert scale. Adoption was defined as active use (≥1 interaction per month) at 12 months post-registration. Data were analysed by one-way ANOVA and logistic regression in R (v4.3.1).

Results

App users applied their first nitrogen top-dressing 4.3 days closer to the growth-model optimum than control farmers (Table 1). Fungicide sprays averaged 1.7 per season in the app group versus 2.2 in the control—a 22% reduction—because the disease-risk module correctly advised skipping the T_1 spray in 63% of fields. Wheat yield was 8.94 t ha^{-1} in the app group, 6.8% above the control (8.37 t ha^{-1}). SMS users fell between the two for all metrics.

Table 1: Crop management indicators and yield across three advisory channels

Indicator	App	SMS	Control
N timing deviation (days)	2.1	3.8	6.4
Fungicide sprays/season	1.7	1.9	2.2
Yield (t ha^{-1})	8.94	8.62	8.37
Satisfaction (1–10)	7.8	6.2	-
12-month adoption (%)	74	48	-

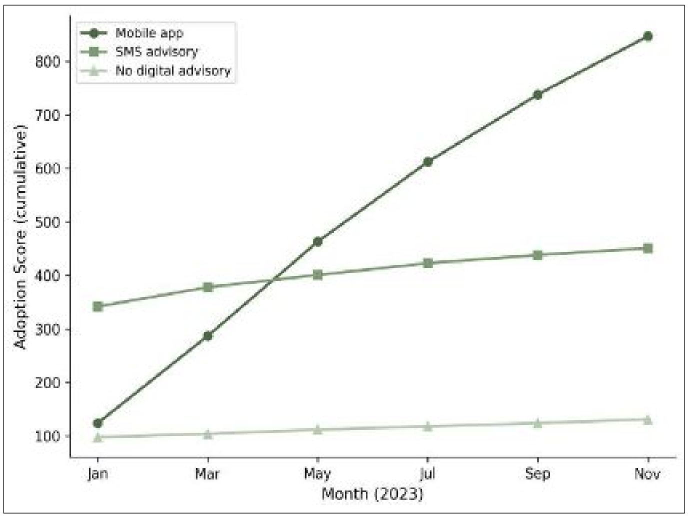

Fig 1: Cumulative adoption score over the 2023 growing season for app, SMS, and control groups.

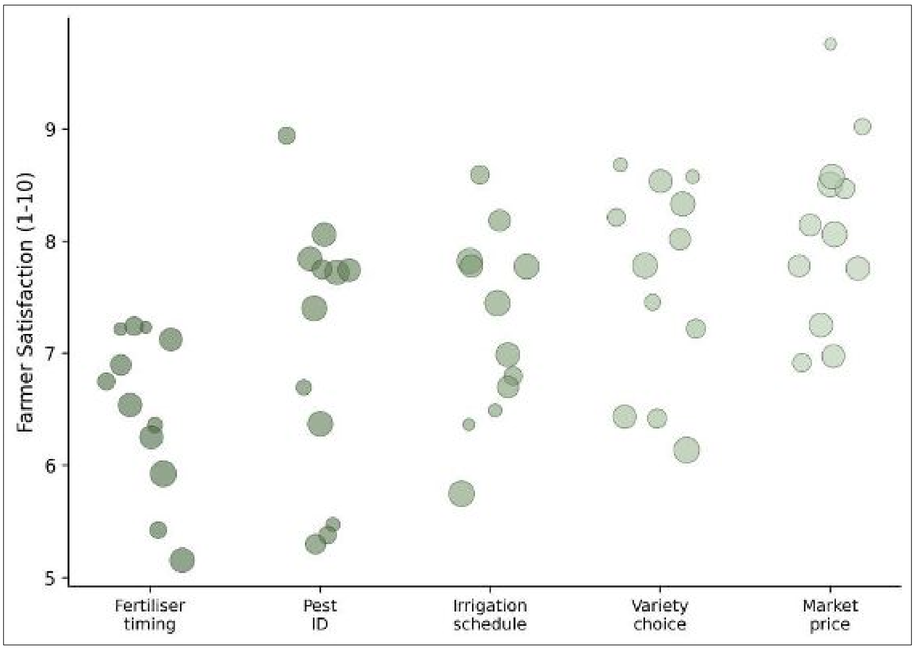

Fig 2: Farmer satisfaction by advisory topic. Bubble size reflects number of queries received on each topic

Comprehensive Interpretation

TAM analysis showed that perceived usefulness (path coefficient 0.54, $p < 0.001$) was a stronger predictor of adoption than ease of use (0.28), consistent with the idea that German farmers are willing to learn a complex tool if it delivers tangible agronomic value [8, 10].

Discussion

The 6.8% yield gain from app-based advisory matches the 5–9% improvements reported in precision-agriculture trials using variable-rate nitrogen in the same region [11]. The fungicide saving of 0.5 sprays per season translates to approximately € 45 ha^{-1} in direct cost plus reduced environmental loading—a result that aligns with European Commission goals under the Farm-to-Fork strategy [12]. The 18% of farmers who dropped out cited poor mobile data coverage in their fields, a known infrastructure gap in rural Lower Saxony that 5G rollout is expected to narrow by 2026 [13].

SMS's intermediate performance suggests it still has a role for farmers who lack smartphones or reliable data, but its ceiling is lower because it can't deliver images or accept field-specific queries [4, 14]. Future iterations of the app should incorporate soil sensor integration and automated spray-log recording to further reduce the farmer's manual data-entry burden.

Conclusion

A smartphone app delivering growth-stage-triggered push notifications improved fertiliser timing, reduced fungicide use, and raised wheat yield by 6.8% compared with no digital advisory. SMS performed moderately. The 74% 12-month adoption rate confirms that interactive mobile platforms have practical traction among German arable farmers. Connectivity remains the main barrier. For extension agencies in Europe, investing in app-based advisory with built-in disease-risk models and image-based pest identification is a cost-effective complement to traditional farm visits [15, 16, 17, 18, 19].

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