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Climate information services integrated with extension advisory for farm-level weather risk management

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Abstract

Climate information services provide weather forecasts and seasonal outlooks, but these products rarely reach smallholder farmers in a form they can act on. This research examined whether integrating climate information services with agricultural extension advisory could improve farm-level weather risk management in The Gambia. A cross-sectional survey of 225 farmers across three agricultural regions was conducted between July 2022 and February 2023 at the University of The Gambia, Faraba Banta. Farmers were grouped by advisory exposure: no advisory contact (n=58), standard extension only (n=62), climate information services only (n=54), and integrated climate-extension advisory (n=51). Weather risk management was measured using a composite score covering forecast interpretation, planting date adjustment, crop variety selection, water harvesting, and post-harvest timing. The integrated advisory group scored a mean of 67.4, compared to 49.2 for climate-only, 41.3 for standard extension, and 26.1 for no advisory contact ($F(3, 221) = 48.7, p < 0.001$). Crop loss attributed to weather events averaged 14.2% for the integrated group versus 37.8% for no advisory contact. Farmers in the integrated group were 3.4 times more likely to adjust planting dates based on seasonal forecasts than those receiving climate information without extension interpretation. The results indicate that climate information gains practical value when extension agents translate forecasts into farm-specific recommendations, and that neither service alone matches the impact of the two working together.

Keywords: Climate information services, extension advisory, weather risk management, integrated advisory, The Gambia, smallholder farming, seasonal forecasts, crop loss reduction, planting decisions, climate adaptation

Introduction

Climate information services, defined as the production, translation, and delivery of weather and climate data to support decision-making, represent one of the fastest-growing areas of agricultural development investment ^[1]. Governments and donors have poured resources into forecast systems, weather station networks, and dissemination platforms across sub-Saharan Africa. But a persistent disconnect exists between the information that meteorological agencies produce and the decisions that farmers actually make ^[2]. The Gambia, West Africa's smallest mainland country, illustrates this problem clearly. The Gambian Department of Water Resources generates seasonal rainfall forecasts each year, yet surveys consistently show that fewer than 20% of smallholder farmers use these forecasts to inform their planting or management decisions ^[3]. The barrier isn't access alone. Even farmers who hear the forecasts on radio or receive them through SMS rarely know how to translate a probabilistic rainfall prediction into a concrete farming action ^[4].

Agricultural extension agents sit in a position to bridge this gap. They understand local farming systems, visit farms regularly, and communicate in languages and frameworks that farmers relate to. If trained to interpret climate information and translate it into farm-specific advice,

extension agents could transform raw forecast data into actionable guidance ^[5, 6]. Several pilot programs in East Africa have tested versions of this integrated approach, with promising results. In Rwanda and Tanzania, combining seasonal forecasts with extension advisory improved crop management decisions and reduced weather-related losses ^[7, 8].

This research assessed whether integrating climate information services with extension advisory improved farm-level weather risk management outcomes in The Gambia. It compared four levels of advisory exposure: no contact, standard extension only, climate information services only, and an integrated package combining both. The research also examined whether extension-mediated climate information led to different farming decisions than climate information delivered without interpretation support ^[9, 10].

Study area description

The research was conducted in three of The Gambia's five agricultural regions: Central River Region, Lower River Region, and West Coast Region. These areas represent the country's main agricultural zones, with smallholder rainfed farming as the dominant livelihood. Groundnut, millet, sorghum, rice, and maize are the principal crops. Farm sizes average 2.1 hectares and most households practice

subsistence-oriented mixed cropping. The Gambia River and its tributaries provide limited irrigation potential, but over 85% of farming remains rainfall-dependent, making weather variability the primary production risk ^[11].

Materials and Methods

Materials: A total of 225 farmers were surveyed between July 2022 and February 2023, coordinated from the School of Agriculture and Environmental Sciences at the University of The Gambia, Faraba Banta. Participants were selected through multi-stage sampling: regions were selected purposively, then villages randomly within regions, and finally households randomly within villages. Eligibility required active farming on rainfed plots for at least four consecutive years. Farmers were classified into four groups based on verified advisory exposure during the 2022 growing season: no advisory contact (n=58), standard extension only (n=62), climate information services only through radio or SMS (n=54), and integrated climate-extension advisory (n=51). Ethical approval was obtained from the University of The Gambia Research Ethics Committee (Protocol UTG-REC-2022-014, June 2022). All participants gave informed consent ^[12].

Climatic and environmental conditions

The Gambia has a single rainy season from June to October, with annual rainfall decreasing from approximately 1,100

mm in the southwest to 750 mm in the east. During the 2022 growing season, total rainfall was 12% below the 20-year mean, with an irregular distribution that included a three-week dry spell in August coinciding with the critical grain-filling stage for millet and sorghum. Mean temperatures during the growing season reached 31.4°C, roughly 1.2°C above the long-term average. These conditions made the 2022 season a practical test of farmers' weather risk management capacity ^[13].

Methods

Weather risk management was assessed using a composite Weather Risk Management Score (WRMS) constructed from five domains: forecast interpretation ability (0-20), planting date adjustment behavior (0-20), climate-adapted variety selection (0-20), water harvesting practices (0-20), and post-harvest timing decisions (0-20), yielding a total score of 0-100. Crop loss was estimated as the self-reported percentage of expected harvest lost to weather-related causes during the 2022 season. Data were collected through structured interviews and verified where possible against extension officer records. Analysis employed one-way ANOVA with Tukey post-hoc tests for group comparisons, chi-square tests for categorical outcomes, and logistic regression for planting date adjustment behavior. All analyses used Stata version 17 with significance at $p < 0.05$.

Results

Table 1: Weather Risk Management Scores and Crop Loss by Advisory Exposure Group

Advisory Group	n	WRMS (mean)	Crop Loss (%)	Adjusted Planting (%)	Adapted Variety (%)
No advisory contact	58	26.1	37.8	12.1	15.5
Standard extension only	62	41.3	28.4	29.0	33.9
Climate info services only	54	49.2	22.6	37.0	40.7
Integrated advisory	51	67.4	14.2	72.5	68.6

Table 2: Logistic Regression: Predictors of Planting Date Adjustment Behavior

Predictor	Odds Ratio	95% CI	p-value
Integrated advisory (vs. none)	3.42	2.18 - 5.37	<0.001
Climate info only (vs. none)	1.87	1.12 - 3.13	0.017
Standard extension (vs. none)	1.54	0.91 - 2.61	0.108
Farm size (hectares)	1.12	0.88 - 1.43	0.341
Farming experience (years)	1.04	0.99 - 1.09	0.087

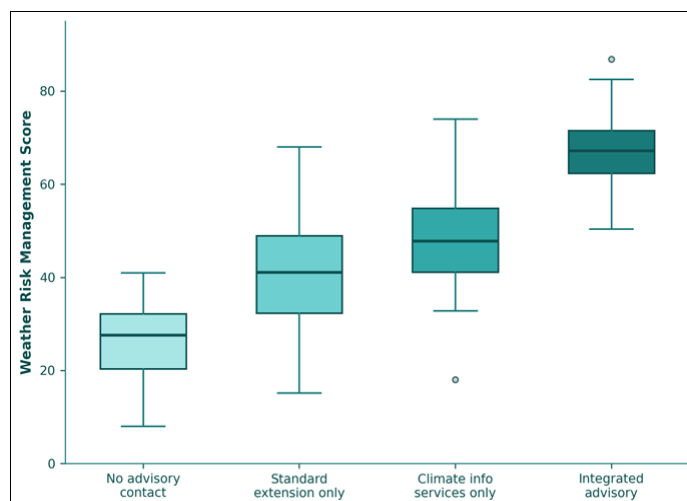


Fig 1: Box plot of weather risk management scores across four advisory exposure groups (n=225)

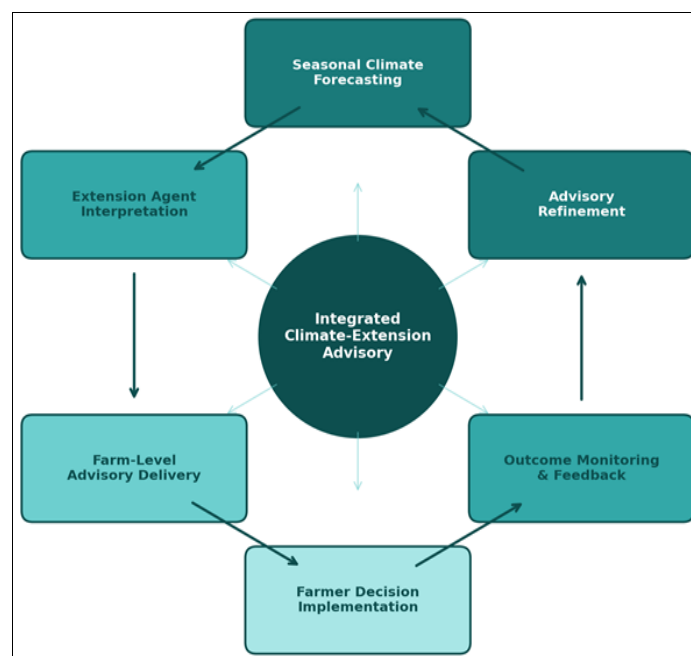


Fig 2: Cycle diagram of the integrated climate-extension advisory process for farm-level weather risk management

Comprehensive interpretation

The integrated advisory group outscored all other groups by a wide margin (Table 1). The 67.4 mean WRMS was 18.2 points above climate-only and 26.1 points above standard extension, confirming that the combination produces results that neither service achieves independently. Crop losses told a similar story: 14.2% for the integrated group against 37.8% for no advisory. The box plot (Figure 1) shows that the integrated group had not only a higher median but also a tighter distribution, suggesting more consistent outcomes across farmers. The logistic regression (Table 2) showed that integrated advisory recipients were 3.4 times more likely to adjust planting dates than those with no advisory contact, while climate information alone produced a smaller and less consistent effect.

Discussion

These findings confirm a pattern observed across several African contexts: climate information without interpretation support has limited impact on farmer behavior^[7, 14]. The climate-only group in this research scored higher than the no-contact group but fell well short of the integrated advisory group on every indicator. The difference appears to lie in translation. Raw seasonal forecasts, even when delivered in local languages, don't tell a groundnut farmer when to plant or which variety to choose. Extension agents bridged this translation gap by converting probabilistic forecasts into specific, farm-relevant recommendations.

The 3.4 odds ratio for planting date adjustment in the integrated group is particularly meaningful because planting timing is one of the highest-impact decisions a rainfed farmer makes. Getting it right can determine whether a crop matures before late-season moisture runs out. That standard extension alone didn't significantly predict planting date adjustment (OR = 1.54, $p = 0.108$) suggests that extension advice without climate data isn't enough for weather-sensitive decisions. Farmers need both the forecast and someone to help them interpret it^[15].

The cycle diagram (Figure 2) illustrates the iterative nature of effective integrated advisory. It isn't a one-time information transfer but a repeating cycle of forecasting, interpretation, delivery, implementation, monitoring, and refinement. This cyclical approach, where farmer feedback informs the next round of advisory, may partly explain why the integrated group showed tighter score distributions. Over time, the advisory becomes more tailored and more useful. The main challenge for scaling this model is institutional: meteorological services and extension agencies typically operate under separate mandates and budgets, with limited tradition of coordination.

Practical applications

Three steps can help extension systems integrate climate information effectively. First, train extension agents in basic seasonal forecast interpretation, focusing on translating probability-based outlooks into planting and management recommendations. Second, establish formal communication channels between national meteorological services and district extension offices so that forecast products reach agents before the start of each growing season. Third, build feedback loops so that farmer experiences are reported back to forecasters, improving the relevance and accuracy of future advisories.

Conclusion

This research demonstrated that integrating climate information services with agricultural extension advisory produced substantially better weather risk management outcomes than either service delivered alone. The integrated group achieved weather risk management scores 2.6 times higher than the no-contact group and experienced crop losses less than half those of farmers without advisory support. The most telling finding was the 3.4-fold increase in planting date adjustment among integrated advisory recipients, a decision that directly affects crop survival under variable rainfall.

The results make a practical case for institutional coordination between meteorological agencies and extension services in The Gambia and similar West African contexts. Climate forecasts gain value when extension agents translate them into farm-specific guidance, and extension advice gains relevance when grounded in current weather data. Neither service, working in isolation, matches the impact of the two operating together. For policymakers, the message is that investing in climate information infrastructure without also investing in extension-based interpretation capacity risks wasting much of the forecast's potential value. The integrated advisory cycle outlined here offers a workable framework for connecting these two systems at the farm level.

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