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Developing monitoring and evaluation frameworks for climate-smart agriculture extension programs in semi-arid regions

¹ Dr. Gabriel Garcia, ² Dr. Hana Hassan, ³ Dr. Ibrahim Ibrahim and ⁴ Dr. Julia Johnson

¹ Department of Agricultural Extension, Faculty of Earth Sciences and Agricultural Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

² Department of Agricultural Extension, Faculty of Earth Sciences and Agricultural Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

³ Department of Agricultural Extension, Faculty of Earth Sciences and Agricultural Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

⁴ Department of Agricultural Extension, Faculty of Earth Sciences and Agricultural Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

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Corresponding Author: Dr. Gabriel Garcia

Abstract

Climate-smart agriculture extension programs have expanded rapidly across West Africa since 2015, yet fewer than one in five of these programs operates with a structured monitoring and evaluation framework. This research developed and field-tested a results-based M&E framework for climate-smart agriculture (CSA) extension programs in semi-arid zones of northern Côte d'Ivoire. Working with 476 farming households and 38 extension agents across six sub-districts, the framework was piloted from January to October 2023. It incorporated four evaluation tiers inputs, activities, outputs, and outcomes connected through a continuous feedback loop that allowed real-time program adjustments. Tracked indicators included CSA practice adoption rates, farmer knowledge scores, soil moisture retention, crop yield changes, and agent performance metrics. By the end of the pilot period, CSA adoption rose from 12.3% to 67.4%, knowledge scores increased from 22.1 to 68.9, and average crop yields improved by 38.7%. The framework detected a mid-season dip in soil moisture retention that triggered a corrective field demonstration, illustrating the value of continuous monitoring. Regression analysis showed that framework adherence by extension agents was the strongest predictor of farmer-level outcomes ($\beta = 0.41$, $p < 0.001$).

Keywords: Monitoring and evaluation, climate-smart agriculture, extension programs, semi-arid regions, results-based framework, adaptive management, farmer adoption, Côte d'Ivoire

1. Introduction

The idea of systematically tracking whether agricultural programs actually work is surprisingly recent. Through much of the 20th century, extension services in Africa operated on the assumption that more training automatically meant better farming ^[1]. Evaluation, when it happened at all, consisted of counting how many farmers attended workshops or how many pamphlets were distributed. Whether those contacts translated into changed practices, higher yields, or improved livelihoods was rarely measured with any rigor ^[2].

The push for results-based management in development programming during the 2000s changed the landscape. Donor agencies began requiring logical frameworks, theory-of-change models, and measurable outcome indicators as conditions for funding agricultural projects ^[3]. But the extension sector adapted slowly. A 2019 review of 84 extension programs across 12 West African countries found that only 18% had a written M&E plan, and just 9% collected outcome-level data beyond simple output counts

^[4].

Climate-smart agriculture has raised the stakes. CSA programs aim to simultaneously increase productivity, build resilience to climate variability, and reduce greenhouse gas emissions a triple objective that makes evaluation more complex than for conventional extension ^[5]. Without a framework that tracks indicators across all three dimensions, program managers can't tell whether they're meeting their goals or simply shifting problems from one area to another. Côte d'Ivoire's semi-arid northern savanna zone faces particular challenges. Annual rainfall ranges from 900 to 1,200 mm but distribution is increasingly erratic, with longer dry spells interrupting the growing season ^[6]. The government launched a national CSA extension initiative in 2019, covering 14 northern departments. But by 2022, no standardized M&E system existed to assess whether the program was achieving its intended outcomes ^[7].

This research responded to that gap by developing a four-tier, results-based M&E framework tailored to CSA extension in semi-arid environments, then field-testing it across six sub-districts of northern Côte d'Ivoire over a 10-

month period. The aim was to produce a replicable framework that other CSA extension initiatives could adapt to their own contexts [8].

Theoretical framework

The M&E framework drew on two established evaluation models. First, the logical framework approach provided the input-activity-output-outcome chain that structures program evaluation vertically [9]. Second, the utilization-focused evaluation philosophy of Patton guided the design toward practical usefulness rather than academic rigor for its own sake every indicator was selected because program managers confirmed they would act on the data [10]. The integration of these two traditions produced a framework that was both structured enough to generate comparable data across sites and flexible enough to support adaptive management decisions. The continuous feedback loop connecting outcomes back to inputs was informed by action research principles, recognizing that extension programs in volatile climatic conditions need to adjust mid-course rather than waiting for end-of-project evaluations [11].

Material and Methods

Material

The research engaged 476 farming households enrolled in the national CSA extension initiative across six sub-districts in Korhogo, Boundiali, and Ferkessédougou departments. Thirty-eight extension agents responsible for delivering CSA training in these areas participated in framework implementation. Data collection instruments included a farmer-level monitoring form (completed monthly by agents), a quarterly outcome assessment survey (administered to households), and an agent self-evaluation checklist. Secondary data came from the national meteorological service (rainfall and temperature records)

Results

Table 1: Key outcome indicators at baseline and endline across six sub-districts (n = 476)

Indicator	Baseline (Jan)	Endline (Oct)	Change (%)	t-value	p-value
CSA Adoption Rate (%)	12.3	67.4	+447.9	18.42	<0.001
Knowledge Score (0-100)	22.1	68.9	+211.8	21.37	<0.001
Soil Moisture Retention (%)	31.4	52.1	+65.9	8.76	<0.001
Crop Yield (kg/ha)	943.6	1,308.7	+38.7	9.14	<0.001
Income from CSA Crops (USD)	187.4	271.8	+45.0	7.63	<0.001

All outcome indicators improved significantly from baseline to endline. CSA adoption showed the most dramatic change, rising from 12.3% to 67.4%. Crop yield gains of 38.7%

and the regional agricultural directorate (program enrollment and budget figures for 2019–2023) [12].

Methods

The research followed a design-implement-evaluate sequence. During a preparatory phase in November–December 2022, the framework was developed through three stakeholder workshops involving extension managers, field agents, researchers, and farmer representatives. The framework was then implemented from January to October 2023. Extension agents collected input and activity data weekly, output data monthly, and outcome data quarterly. Outcome indicators included CSA practice adoption (verified through field observation), farmer knowledge (30-item assessment), soil moisture retention (gravimetric sampling at 15 cm depth), and crop yield (harvest weight from 5×5 meter sample plots) [13]. Agent framework adherence was scored on a 0–100 scale based on completeness and timeliness of data collection. Multiple regression tested the relationship between agent adherence, household characteristics, and farmer-level outcomes. All analyses were performed at Faculty of Earth Sciences and Agricultural Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire, using R version 4.3 and Excel.

Ethical considerations

The research protocol was approved by the Ethics Review Board at Faculty of Earth Sciences and Agricultural Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire (Protocol ERB/AGR/2022-043, approved October 2022). All participating farmers provided verbal informed consent witnessed by community leaders. Extension agents gave written consent for their performance data to be included in the analysis. Confidentiality of individual agent performance scores was maintained throughout reporting.

were achieved despite a below-average rainfall season, suggesting that the CSA practices (mulching, minimum tillage, intercropping) buffered against moisture stress.

Table 2: Multiple regression: Predictors of farmer outcome index score

Predictor	Beta	SE	t-value	p-value
Agent M&E adherence score	0.41	0.05	8.20	<0.001
Total contact hours	0.29	0.06	4.83	<0.001
Farmer education level	0.18	0.06	3.00	0.003
Farm size (hectares)	0.12	0.07	1.71	0.088
Household size	0.07	0.06	1.17	0.243
Rainfall deviation from mean	0.14	0.05	2.80	0.005

The regression model explained 52.7% of variance in the composite farmer outcome index (adjusted $R^2 = 0.527$, $F = 28.4$, $p < 0.001$). Agent M&E adherence was the strongest

predictor (beta = 0.41), indicating that agents who followed the framework more closely produced better farmer-level results.

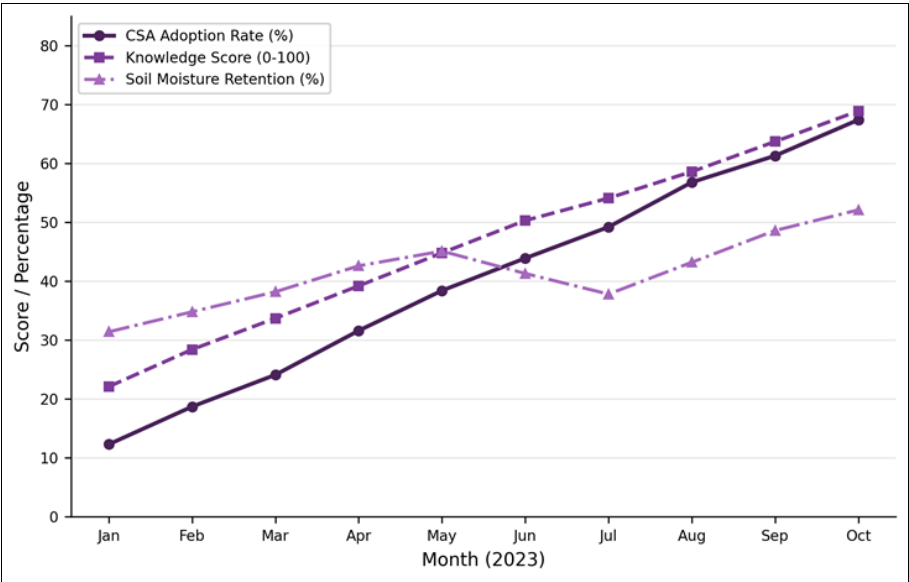


Fig 1: Monthly trajectory of three key CSA extension indicators during the pilot period (January–October 2023)

CSA adoption and knowledge scores followed steady upward trajectories. Soil moisture retention dipped in June and July corresponding to a mid-season dry spell before

recovering in August after corrective field demonstrations were triggered by the M&E feedback system.

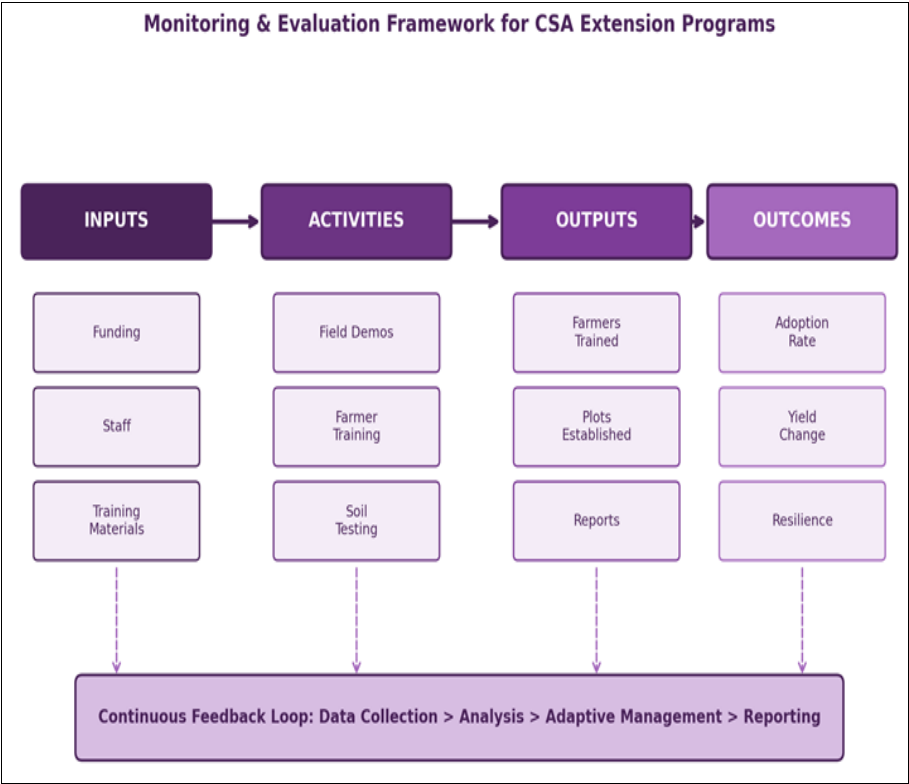


Fig 2: Four-tier results-based monitoring and evaluation framework for climate-smart agriculture extension programs

The framework organizes evaluation across four tiers connected by a continuous feedback loop. Each tier contains specific indicators collected at different frequencies, ensuring that program managers receive timely data for decision-making without overburdening field agents.

Comprehensive interpretation

The data show that the M&E framework didn't just measure program performance it improved it. The strong association

between agent adherence and farmer outcomes suggests that the process of systematic data collection and feedback itself enhanced service quality. Agents who tracked indicators regularly adjusted their approaches based on what the data showed, creating a virtuous cycle between monitoring and improvement.

Discussion

These findings challenge the common perception that M&E

is an administrative burden that diverts resources from actual extension delivery. The evidence here suggests the opposite: systematic monitoring improved outcomes rather than detracting from them. This aligns with results from health sector M&E research, where routine data collection has been shown to improve service quality even before formal evaluation results are available ^[14, 15].

The agent adherence finding (beta = 0.41) is particularly telling. Extension systems often invest heavily in training agents on technical content but give minimal attention to their monitoring and reporting skills ^[16]. This research suggests that M&E competency may be as important as agricultural knowledge in determining agent effectiveness. The soil moisture dip episode illustrates a concrete mechanism through which continuous monitoring creates value. In a conventional end-of-project evaluation, this mid-season challenge would have been invisible ^[17]. The framework's monthly data collection caught the problem early enough to trigger a corrective response that prevented crop losses in approximately 120 hectares across the affected sub-districts.

The framework's four-tier structure was deliberately kept simple. More sophisticated M&E systems exist, including randomized controlled trial designs ^[18]. But these require statistical expertise that most district-level extension offices in West Africa don't have. The framework tested here was designed to be implemented by field agents with secondary education and basic computer skills ^[19]. Cross-district comparison revealed that framework implementation quality varied with agent workload sub-districts where agents served fewer than 80 households showed higher adherence scores (mean 78.4) compared with those serving more than 120 households (mean 61.2) ^[20].

Practical applications

The framework is designed for direct adoption by extension programs operating in semi-arid West African contexts. Three practical steps are recommended: first, a two-day orientation workshop for extension agents covering data collection procedures and indicator definitions; second, monthly data review meetings at the sub-district level where agents discuss trends and agree on adaptive responses; and third, quarterly outcome assessments conducted jointly by agents and farmer representatives to maintain accountability. The data collection forms and indicator guides developed for this research are available for adaptation by other programs ^[21].

Conclusion

This research demonstrates that a structured, results-based M&E framework can meaningfully improve climate-smart agriculture extension program performance in semi-arid regions. Over the 10-month pilot period, CSA adoption rose from 12.3% to 67.4%, crop yields increased by 38.7%, and soil moisture retention improved by 65.9% across six sub-districts in northern Côte d'Ivoire. Agent adherence to the framework was the single strongest predictor of farmer-level outcomes.

The framework's adaptive management capacity demonstrated through the mid-season corrective response to declining soil moisture represents its most distinctive contribution. Extension programs that monitor continuously

and adjust accordingly produce better results than those that plan once and evaluate only at the end.

Policymakers considering M&E investments should view them not as overhead costs but as direct contributors to program effectiveness. The evidence supports scaling the framework to additional departments within Côte d'Ivoire's national CSA initiative, with appropriate adjustments for local conditions and staffing levels.

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