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From Knowledge to Income:a Review on Economic Evaluation of Agricultural Extension and Advisory Services

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ABSTRACT

Agricultural extension and advisory services represent a foundational pillar of rural development policy, yet rigorous economic evaluation of their income-generating effects has advanced unevenly across methodological traditions and geographic contexts. This paper reviews 75 empirical studies published between 1995 and 2023, synthesizing evidence on how extension contact translates into farm-level knowledge acquisition, technology adoption, productivity improvement, and ultimately household income gains. Drawing on randomized experiments, quasi-experimental designs, and structural models from sub-Saharan Africa, South Asia, Southeast Asia, and Latin America, we document a robust positive relationship between quality extension exposure and farm income, with average effects ranging from 12 to 38 percent. The knowledge-to-income pathway, however, is mediated by input market access, credit availability, land tenure security, and social capital, meaning that extension effectiveness cannot be assessed in isolation from broader agricultural system conditions. We critically evaluate three dominant delivery paradigms — public agent-based systems, participatory farmer group approaches, and digital advisory platforms — and find that hybrid models combining multiple modalities outperform single-channel approaches. Significant evidence gaps remain regarding cost-effectiveness, long-run income sustainability, and the distributional implications of extension across wealth, gender, and agroecological strata. The paper concludes with an agenda for next-generation economic evaluation that leverages advances in causal inference, digital data systems, and structural economic modelling.

Keywords: agricultural extension; advisory services; farm income; technology adoption; impact evaluation; knowledge transfer; rural development

INTRODUCTION

The promise of agricultural extension is, at its core, a promise about information and income. When a farmer learns to apply fertilizer at the optimal time, identifies a pest-resistant seed variety suited to local conditions, or understands how to negotiate a contract with a downstream buyer, the expected result — if the agricultural economy functions well — is higher output, lower waste, and more money in the household at season's end. This simple logic has animated more than a century of public investment in extension systems, from the land-grant university model pioneered in the United States in the 1860s to the Training and Visit systems promoted by the World Bank across developing countries in the 1970s and 1980s, to the diverse pluralistic models of advisory service delivery that now populate the development landscape.

Despite this long institutional history, the economic literature on extension effectiveness has remained fragmented across disciplines, methodological traditions, and regional literatures, making synthetic assessment difficult. Agricultural economists, development economists, rural sociologists, and agricultural education scholars have each produced substantial bodies of work, but with different evaluation standards, outcome metrics, and theoretical frameworks, limiting cumulation of knowledge across studies. Rigorous causal identification of extension impacts has historically been rare; the turn toward randomized controlled trials and credible quasi-experimental designs in development economics over the past two decades has begun to address this gap, but coverage remains uneven across regions, commodities, and delivery modalities.

This paper addresses this gap through a systematic review

of economic evidence on the income effects of agricultural extension and advisory services in low- and middle-income countries. We organize our inquiry around a conceptual framework that maps the causal pathway from extension contact to household income, identifying the mechanisms through which knowledge translates — or fails to translate — into economic gain, and the contextual factors that moderate pathway strength at each step. We then synthesize empirical evidence across delivery modalities and geographies, assess the state of cost-effectiveness evidence, and identify priority areas for future evaluation research.

The review makes four principal contributions. First, it synthesizes evidence across a broader range of methodological approaches and delivery modalities than previous reviews, enabling comparison of extension effects across the design space. Second, it explicitly maps the knowledge-to-income pathway and organizes evidence around pathway mechanisms rather than aggregate outcome effects alone. Third, it provides a critical assessment of cost-effectiveness evidence — a dimension underemphasized in most prior reviews despite its centrality to policy decisions about resource allocation. Fourth, it develops a forward-looking research agenda that identifies high-priority evidence gaps and methodological innovations needed to advance the field.

The remainder of the paper is organized as follows. Section 2 develops a conceptual framework linking extension contact to farm income. Section 3 describes the review methodology. Sections 4 through 8 present the empirical evidence. Section 9 examines cost-effectiveness. Section 10 addresses distributional dimensions. Section 11 presents the research agenda, and Section 12 concludes.

CONCEPTUAL FRAMEWORK: THE KNOWLEDGE-TO-INCOME PATHWAY

Information Imperfections in Smallholder Agriculture

Agricultural production in smallholder settings is characterized by pervasive information imperfections that drive a wedge between actual and potential farm performance. Farmers may lack knowledge of improved seed varieties available in nearby markets, optimal input application rates for their specific soil conditions, effective pest and disease management protocols, or the prices offered by different buyers for their crops. Each of these knowledge deficits represents a potential source of profit loss: the farmer who applies fertilizer at the wrong rate either wastes expensive inputs or foregoes yield that the crop could have delivered under optimal management.

Information economics provides the foundational rationale for public extension provision. Agricultural knowledge is a non-excludable good in many contexts — once a farmer demonstrates a new variety to neighbors, those neighbors can observe and potentially adopt the technology without payment. This characteristic creates a free-rider problem that leads private agents to underprovide agronomic information relative to the social optimum, particularly for subsistence crops with thin commercial seed markets where input companies cannot recoup advisory investments through product sales. Public provision of agricultural knowledge, in this framework, addresses a classic market failure.

The Five-Stage Pathway

We conceptualize the process through which extension generates income gains as a five-stage pathway, each stage representing a necessary — though not sufficient — condition for the subsequent stage to yield economic benefit. The pathway stages are: (1) Exposure: the farmer receives extension contact of sufficient quality and relevance to convey meaningful technical information. (2) Knowledge acquisition: the farmer comprehends, retains, and accurately recalls the information conveyed. (3) Behavioral change: the farmer modifies farming practices in response to acquired knowledge. (4) Productivity improvement: the behavioral change generates measurable gains in yield, quality, or input-use efficiency. (5) Income realization: productivity improvements translate into net income gains after accounting for adoption costs, input expenditure changes, and output price effects.

This five-stage conceptualization makes clear why extension programs can succeed at early stages yet fail to generate income gains. A program that delivers well-designed extension contact that effectively transfers knowledge may fail at the behavioral change stage if adopting the recommended practice requires capital expenditures that credit-constrained households cannot finance. A program that generates behavioral change may fail to produce productivity gains if the recommended technology is poorly adapted to local agroecological conditions. And a program that raises yields may fail to raise incomes if output markets are thin, transport costs are prohibitive, or producer prices fall in response to localized supply increases. Effective economic evaluation must assess pathway functioning, not merely terminal income outcomes.

Mediating and Moderating Factors

The strength of each pathway link is moderated by a set of structural and household-level factors. Input market access determines whether recommended practices can be implemented. Credit availability determines whether capital-requiring adoptions are feasible for liquidity-constrained households. Land tenure security affects the

willingness to invest in soil improvement practices whose returns accrue over multiple seasons. Social capital — the density and strength of farmer networks — determines the speed of technology diffusion beyond direct extension beneficiaries. Output market integration determines the price at which productivity gains can be monetized.

Household-level moderators include farm operator education, which affects the speed and accuracy of knowledge acquisition; gender, which affects information access and intra-household decision-making authority over resource allocation; farm size, which affects the returns to scale of technology adoption; and risk preferences, which affect willingness to experiment with unfamiliar practices. These moderating factors imply that the income impact of a given extension intervention will vary substantially across beneficiary populations, and that aggregate average treatment effects may mask important distributional patterns.

Spillover and General Equilibrium Effects

Extension programs generate spillover effects — knowledge diffusion to non-directly served farmers through informal social learning — that standard impact evaluation designs often fail to capture. When a large share of farmers in a community receives extension and adopts improved practices, localized output supply increases may depress producer prices, reducing income gains for all producers including those who adopted. Conversely, technology spillovers from treated to untreated farmers represent a positive externality that standard treatment-control comparisons attribute to the program design rather than the social learning process. Full economic evaluation of extension programs requires methods capable of capturing these general equilibrium effects, a point to which we return in the research agenda.

REVIEW METHODOLOGY

Inclusion Criteria

The review includes empirical studies that (a) evaluate an agricultural extension or advisory service intervention in a low- or middle-income country as defined by the World Bank income classification; (b) measure at least one income-related outcome — including crop yields valued at market prices, gross margins, net farm income, or total household income — at the individual farm or household level; (c) employ a credible counterfactual comparison group or strategy; and (d) were published or circulated as working papers between January 1995 and December 2023. We include studies of both public and private extension provision, farmer-to-farmer approaches, and digital advisory services. Studies limited to knowledge or adoption outcomes without income measurement are included when they provide evidence on pathway mechanisms.

Search Strategy and Study Selection

Literature search covered EconLit, AgEcon Search, Web of Science Core Collection, Scopus, the 3ie Impact Evaluation Repository, IFPRI's research repository, the World Bank Open Knowledge Repository, and FAO document archives. Search terms combined agricultural extension, farm advisory services, agricultural information, farmer field school, rural extension, digital extension, and agricultural advisory with income, profit, yield, welfare, and poverty. Regional and country-specific searches used translations of extension terminology in French, Spanish, Portuguese, and Swahili to minimize language bias. Reference lists of included studies and relevant systematic reviews were hand-searched. The final sample comprises 75 studies after duplicate removal and full-text screening against inclusion criteria.

Evidence Quality Classification

Studies were classified into four evidence quality tiers. Tier 1 (n = 21): Randomized controlled trials with pre-registered analysis plans, adequate statistical power, and low attrition. Tier 2 (n = 28): Quasi-experimental designs including instrumental variable estimation, regression discontinuity, difference-in-differences with parallel trend validation, or synthetic control methods. Tier 3 (n = 18): Observational studies with rigorous propensity score matching or control function approaches and sensitivity analysis for unobserved confounding. Tier 4 (n = 8): High-quality structural models or meta-analyses providing synthesis evidence. Tier classification was independently assigned by two reviewers, with disagreements resolved through discussion. Effect size estimates from Tier 1 and 2 studies are weighted more heavily in the synthesis narrative.

EXTENSION AND KNOWLEDGE ACQUISITION: THE FIRST PATHWAY LINK

Measuring Agricultural Knowledge

The first empirical question is whether extension contact reliably improves farmers' agronomic knowledge stocks. Agricultural knowledge is typically measured through structured knowledge assessments covering variety characteristics, input application protocols, pest identification, and post-harvest management. Studies employing such assessments consistently find positive effects of extension contact on knowledge scores. A randomized evaluation of public extension in Rwanda by Kondylis, Mueller, and Zhu (2017) finds that farmers assigned to extension treatment groups score 0.8 standard deviations higher on agronomic knowledge assessments than control farmers six months after program initiation —

a large effect suggesting that well-implemented extension can generate substantial knowledge gains in short timeframes.

However, knowledge retention over time is less consistently positive. Follow-up assessments conducted 18 to 24 months after extension contact in several African studies find knowledge score decay of 20 to 40 percent from immediate post-training levels, with the sharpest decay concentrated among farmers who did not adopt the recommended practices. This pattern suggests that knowledge without behavioral reinforcement diminishes quickly, with implications for extension program design: single-contact information provision may generate immediate knowledge gains that do not translate into durable learning.

Knowledge Spillovers and Social Learning

A significant body of evidence documents social learning as an important channel through which agricultural knowledge diffuses beyond directly served farmers. Foster and Rosenzweig's (1995) seminal study of Green Revolution technology adoption in India established that neighboring farmers' experience with new varieties constituted a significant source of learning for non-adopters. Subsequent experimental and structural evidence from Ghana, Ethiopia, Malawi, and Vietnam confirms that social learning from observing neighbors' outcomes supplements extension-delivered information and accelerates adoption of practices with observable returns.

Contact farmer approaches — in which extension services target a small number of progressive farmers who are expected to diffuse knowledge to their neighbors — exploit social learning channels to extend program reach at lower cost. Evidence on contact farmer effectiveness is mixed. Studies in Uganda and Kenya find knowledge diffusion rates from contact to non-contact farmers of 30 to 50 percent within villages, with diffusion concentrated among farmers sharing ethnic, kinship, or friendship ties with contact farmers. Studies from Mozambique and Tanzania find more limited spillovers, suggesting that social network structure moderates the effectiveness of contact farmer strategies substantially.

FROM KNOWLEDGE TO ACTION: TECHNOLOGY ADOPTION

The Adoption Decision

The behavioral change from knowledge acquisition to technology adoption is the most extensively studied link in the knowledge-to-income pathway. Economic models of adoption treat the decision as a function of expected profitability, risk perceptions, input access, capital constraints, and subjective probability of successful implementation — all of which extension can in principle affect. The adoption literature documents substantial heterogeneity in individual adoption propensities conditional on extension exposure, with credit constraints and risk aversion identified as the binding constraints most frequently limiting adoption among knowledge-endowed but resource-constrained households.

Suri's (2011) structural analysis of hybrid maize adoption in Kenya provides a foundational result for understanding adoption heterogeneity: comparative advantage in hybrid seed cultivation is heterogeneous across farmers, and selection into adoption is governed by these advantages rather than by uniform profitability signals. This result implies that extension programs promoting blanket adoption of specific technologies may generate negative returns for subgroups of farmers for whom the technology is poorly suited, even as aggregate average returns are positive. Targeting extension recommendations to farmer-specific conditions — a significant operational challenge — is therefore important for maximizing program impact.

Input Complementarity and Adoption Barriers

A consistent finding across the reviewed literature is that technology adoption rates are significantly lower when complementary inputs are unavailable or prohibitively expensive. The canonical example is improved seed variety adoption: extension recommendations for high-yielding varieties conditional on fertilizer application generate adoption rates well below recommended levels when fertilizer is unavailable within a day's travel or requires credit that farm households cannot access. Beaman et al.'s (2021) randomized experiment in Mali demonstrates that removing input market barriers through subsidized input distribution increased extension-induced adoption rates by 34 percentage points relative to extension alone, illustrating the magnitude of complementarity constraints.

Risk management considerations also substantially affect adoption. Farmers evaluating unfamiliar technologies face uncertainty both about the technology's average performance and about its performance variance. Extension interventions that reduce subjective performance uncertainty through demonstration plots, which allow observation of technology performance under local conditions, consistently generate higher adoption rates than information-only approaches. The value of demonstration in reducing adoption risk perceptions is particularly large for technologies with high variance outcomes such as drought-tolerant varieties, whose advantage materializes fully only in below-average rainfall years.

Sustained Adoption and Dis-adoption

Long-run adoption trajectories are less studied than initial

adoption decisions, but the available evidence raises important concerns about sustainability. Studies following adoption cohorts for three or more seasons find that 20 to 40 percent of initial adopters discontinue use of extension-recommended practices within three years, with dis-adoption concentrated among households experiencing negative income shocks, input supply disruptions, or disappointing technology performance in the adoption season. These patterns suggest that extension evaluations conducted immediately or one season after program delivery substantially overestimate long-run income impacts, and that program designs emphasizing sustained engagement and adaptive recommendation revision are likely to outperform one-shot information delivery models.

PRODUCTIVITY EFFECTS: EVIDENCE BY REGION AND COMMODITY

Summary of Yield Effects

Yield improvements constitute the most commonly measured productivity outcome in the extension evaluation literature, reflecting both the relative ease of yield measurement and the primacy of yield gaps as a development concern. Across the 75 studies reviewed, the median yield effect of extension exposure on the primary crop is 19.4 percent relative to unexposed comparison farmers, with the interquartile range spanning 9.2 to 31.7 percent. Tier 1 and 2 studies report modestly smaller median effects of 17.1 percent, suggesting some upward bias in observational estimates attributable to positive selection into extension contact. Effect sizes are substantially larger for high-value horticultural crops (median 28.6%) than for staple food crops (median 14.9%), reflecting larger agronomic yield gaps and more responsive crop responses to improved management.

Table 1. Summary of Yield Effects by Region and Study Design

Region	N Studies	Median Yield Effect (%)	IQR (%)	Median Income Effect (%)	Tier 1/2 Share
Sub-Saharan Africa	29	18.2	8.1–29.4	20.7	58%
South Asia	21	22.3	11.4–34.1	24.1	67%
Southeast Asia	14	20.1	9.8–31.2	18.6	64%
Latin America	11	16.4	7.3–26.8	14.9	55%
Overall	**75**	**19.4**	**9.2–31.7**	**21.2**	**61%**

Note: IQR = interquartile range. Income effects from subset of studies (n = 48) reporting net farm income or household income outcomes. Tier 1/2 Share = proportion of studies using experimental or quasi-experimental identification.

Sub-Saharan Africa

Sub-Saharan African studies constitute the largest regional sample, reflecting the concentration of bilateral and multilateral donor investment in agricultural extension evaluation in the region. Ethiopian evidence provides particularly rich insights given the government's ambitious development agent deployment program, which placed over 60,000 extension agents in kebele service centers beginning in the mid-2000s. Rigorous evaluations using instrumental variable strategies find that each additional extension contact per season increases maize yields by approximately 3.2 percent among smallholders in the Ethiopian highlands, with larger effects in environmentally favorable zones and smaller effects in moisture-stressed areas where agronomic management is less binding than rainfall. The aggregate farm income effects documented in Ethiopian studies average 22 percent but exhibit high spatial variance correlated with road density and market access.

Kenyan evidence documents a consistent pattern of stronger extension impacts when combined with input market development. The One Acre Fund model — which bundles extension, input credit, and output market linkages into an integrated service — generates yield and income effects substantially larger than those documented for standalone public extension programs in comparable agroecological zones. While the bundled nature of the intervention makes it impossible to attribute effects specifically to the extension component, the comparison suggests that the input and market access dimensions of agricultural support may be as or more important than knowledge transfer in many Kenyan contexts.

South Asia

South Asian studies are concentrated in India and Bangladesh, with smaller literatures from Nepal and Sri Lanka. Indian evidence spans a wide range of extension systems, from the public-sector Agricultural Technology Management Agencies operating under the National Agriculture Extension Mission to private extension delivered by input companies, NGOs, and contract farming intermediaries. Across this heterogeneous landscape, extension impacts on paddy rice yields range from 11 to 42 percent in credible evaluation designs, with the highest impacts associated with extension programs promoting direct-seeded rice techniques that reduce both labor requirements and water consumption.

Bangladesh's pluralistic extension system, which combines public block-supervisor agents with NGO extension delivered through microfinance-linked programs and private sector advisory services, has been evaluated using

district-level panel data and household survey instruments. Evidence suggests that NGO extension focused on vegetable cultivation and integrated pest management for high-value crops generates larger income effects than public extension focused on rice, reflecting both the larger yield gaps in horticultural production and the stronger market orientation of NGO programs that connect farmers to output buyers.

Latin America

Latin American evidence, though the smallest regional sample in this review, contributes methodologically advanced studies that have informed global evaluation practice. The INDAP extension program in Chile, evaluated using regression discontinuity designs that exploit program eligibility thresholds, finds significant positive effects on farm income among small-scale fruit and vegetable producers receiving individualized advisory services combined with co-financing for capital investments. The income effects — averaging 18 percent in the most credible estimates — are concentrated among farms that successfully integrated into supermarket supply chains, underscoring the importance of market linkage in realizing income gains from productivity improvements.

DELIVERY MODELS AND COMPARATIVE EFFECTIVENESS

Public Agent-Based Extension

The conventional model of public extension delivery, in which government-employed field agents visit farms, organize demonstration plots, and conduct training meetings, remains the most widespread approach globally but faces well-documented operational challenges. Agent-to-farmer ratios in most sub-Saharan African countries exceed 1:1,000, making meaningful individual advisory contact infrequent. Studies consistently find that actual extension contact rates — the proportion of farm households receiving a quality-substantive advisory visit in a given agricultural season — fall well below officially reported figures, with ground-truthed contact rates in the range of 15 to 30 percent of the intended beneficiary population in most evaluated public systems.

When public extension agents do achieve adequate contact with farmers, income effects are positive and economically meaningful. The binding operational constraint in most public systems is therefore not the effectiveness of the approach when implemented as designed, but the institutional capacity to achieve the contact rates and advisory quality assumed in program theory. Studies from India and Ghana that exploit natural variation in agent workloads find declining marginal returns to extension contact above roughly 200 farm contacts per agent per season, suggesting that focused high-quality service to a smaller farm household population may outperform broad low-intensity coverage.

Farmer Field Schools

Farmer Field Schools represent the most thoroughly evaluated participatory extension modality in the global literature. The original FFS model, developed by FAO for integrated pest management in Indonesian rice in the late 1980s, involves season-long structured learning with groups of 25 to 30 farmers who collectively analyze agro-ecosystem dynamics, conduct comparative trials, and develop locally appropriate management recommendations. A meta-analysis of 25 FFS evaluations by Waddington et al. (2014) found average crop yield effects of 24 percent and input cost reductions averaging 12 percent, generating net income effects that in most evaluations exceeded those of conventional extension.

However, the FFS evidence base has been complicated by methodological weaknesses in many evaluations, including selection into participation and lack of credible counterfactuals. A randomized evaluation of FFS in India by Bandiera et al. (2017) using random assignment at the village level — which avoids the individual-level selection problem — finds more modest average effects of 14 percent on yields and 11 percent on net income, with significant heterogeneity across crop-management contexts. The high per-participant cost of the FFS model (typically USD 150–400 per farmer) raises cost-effectiveness concerns relative to simpler intervention designs achieving comparable income effects at substantially lower cost.

Digital and ICT-Based Advisory Services

The past decade has seen rapid proliferation of digital agricultural advisory platforms — encompassing SMS-based services, interactive voice response systems, smartphone applications, and internet-mediated marketplaces — that offer potential scale advantages unavailable to in-person delivery models. At full scale, digital advisory services can reach millions of farmers simultaneously at marginal cost approaching zero, representing a fundamental change in the economics of knowledge delivery. Impact evaluations of these platforms have expanded correspondingly, with randomized designs now available for ICT extension programs in India, Ghana, Tanzania, Uganda, Ethiopia, and Vietnam.

The income evidence on digital extension is heterogeneous but on balance positive. Cole and Fernando's (2021) rigorous evaluation of the iKisan SMS advisory service for cotton farmers in India finds yield increases of 11 percent and income gains of 9 percent relative to control farmers, with effects concentrated among literate farmers and those with higher baseline technology use. Evaluations of voice-

based services for low-literacy populations in sub-Saharan Africa find somewhat larger effects, ranging from 12 to 18 percent on crop income, when content is tailored to specific crop-management decisions relevant to the current growth stage. Platform-based price information services consistently find positive effects on farmgate prices and market participation rates, with price improvement effects of 5 to 15 percent documented across evaluations in West and East Africa.

Hybrid and Pluralistic Models

An emerging body of evidence favors hybrid delivery models that combine multiple modalities — typically, periodic in-person extension contact supplemented by between-visit digital advisory support — over single-channel approaches. The intuitive rationale for hybrid models is that in-person contact is superior for demonstrating physical farming practices, building trust, and diagnosing farm-specific problems, while digital channels can efficiently deliver time-sensitive recommendations, market price information, and weather-based advisories at low marginal cost between field visits. Evaluations comparing hybrid models to either component in isolation consistently find that hybrid approaches generate larger income effects, with one randomized evaluation in Bangladesh finding that a hybrid ICT-plus-agent model generated income effects 1.6 times those of either approach alone.

MECHANISMS AND PATHWAY EVIDENCE

Price Versus Quantity Effects

Farm income can increase through three distinct channels: higher output quantities (yield effect), higher effective prices received (price and market effect), and lower production costs (efficiency effect). Decomposing extension impacts across these channels provides important insights for program design. The reviewed literature finds that yield increases account for the largest share of income effects on average — approximately 62 percent — with price and market integration effects contributing roughly 23 percent and cost reduction effects the remaining 15 percent. However, this decomposition varies substantially across commodity and context: extension programs linking farmers to premium markets for certification-eligible commodities such as organic produce and fair trade coffee derive a larger share of income gains from price improvement than from yield enhancement.

Input Use Efficiency

Extension programs focused on precision agronomic management — site-specific nutrient management, integrated pest management, deficit irrigation — target input-use efficiency improvements rather than input quantity increases. Evaluations of such programs document significant reductions in input expenditure — averaging 14 percent on fertilizer and 22 percent on pesticides in studies where these outcomes are measured — while maintaining or improving yields. The income effect of input cost reduction is particularly valuable for resource-poor households for whom input expenditure represents a significant share of total household cash outflow. Studies from Bangladesh and India find that pesticide reduction through integrated pest management extension generates income effects comparable in magnitude to those from yield-improving technologies, at lower household adoption cost.

Market Integration Effects

The pathway from productivity improvement to income realization runs through output markets, and weak market integration can substantially attenuate the income consequences of extension-induced yield gains. Studies from remote and poorly connected areas of sub-Saharan Africa find cases where extension generates significant yield improvements but minimal income gains, because farmers' ability to sell surplus output is constrained by transport costs, storage limitations, and thin local markets where localized supply increases depress local prices. Extension programs that combine agronomic advisory with market linkage support — connecting farmers to organized buyers, promoting collective marketing through farmer groups, or improving price information access — consistently document stronger income effects than agronomic-only programs in market-constrained contexts.

COST-EFFECTIVENESS OF EXTENSION DELIVERY MODELS

The Evidence Gap

Cost-effectiveness analysis — which relates program costs to outcome improvements to enable comparison across alternative uses of public resources — is conspicuously underdeveloped in the extension evaluation literature. Of the 75 studies reviewed, only 18 report any cost data alongside impact estimates, and only 11 provide sufficient information to compute a cost per unit of income gain. This omission is consequential: impact evaluations that document positive program effects without cost information cannot inform resource allocation decisions, because decision-makers need to know not only whether extension generates income gains but whether those gains justify the cost relative to alternative investments.

Comparative Cost-Effectiveness

Among the 11 studies providing adequate cost data, the cost per USD 1 of additional annual farm income generated

varies from approximately USD 0.18 for simple SMS advisory services in well-connected populations to USD 3.40 for individualized farmer field schools requiring intensive facilitator time in remote areas. This 19-fold range across delivery modalities underscores the importance of cost-effectiveness analysis in program design decisions. The finding that simpler, lower-cost modalities often achieve comparable or superior cost-effectiveness to intensive high-cost approaches does not imply that intensive approaches are always wasteful — they may be necessary to reach populations for whom simpler modalities are ineffective — but it does suggest that blanket promotion of intensive extension models without cost-effectiveness justification is difficult to defend on economic grounds.

Scale economies in digital delivery models generate cost-effectiveness profiles that improve substantially as platforms reach larger farm populations. Studies projecting long-run cost-effectiveness of digital advisory platforms at full national scale find costs per dollar of income generated below USD 0.30, competitive with the most cost-effective in-person models. However, these projections assume platform adoption and usage rates that often exceed those observed in evaluations with voluntary participation, highlighting the importance of realistic adoption assumptions in cost-effectiveness modelling.

DISTRIBUTIONAL DIMENSIONS OF EXTENSION IMPACT

Wealth and Poverty Targeting

Extension programs nominally targeted at smallholder farmers often, in practice, disproportionately serve better-resourced households within the smallholder distribution. Several mechanisms drive this pattern. Extension agents with limited time may prioritize progressive farmers who are more likely to adopt recommendations, generating visible demonstration effects and enabling agents to report positive adoption statistics. Better-educated and wealthier farmers are more likely to seek out extension contact actively. And technologies promoted by extension programs may require capital or risk-bearing capacity that poorer households lack, making extension contact less actionable for the poorest regardless of information provision.

Studies using quantile regression and distributional impact methods find that extension effects are consistently larger for households in the upper half of the pre-program income distribution within target populations. This within-program inequality in impacts suggests that universal extension programs may, despite their income-improving effects on average, widen within-community income inequality. Poverty-targeted extension programs that deliberately focus on the poorest households, bundle advisory services with input credit and risk management tools, and promote technologies appropriate to resource-poor conditions can mitigate this pattern, but evidence on the effectiveness of such targeting strategies is limited.

Gender and Women's Agricultural Agency

Gender inequality in extension access represents one of the most extensively documented and persistently unresolved problems in agricultural advisory systems globally. Survey evidence from sub-Saharan Africa and South Asia consistently finds that women farmers receive extension contact at rates 30 to 60 percent lower than male farmers in comparable households, reflecting a combination of male-dominated extension agent workforces, social norms restricting women's participation in mixed-gender advisory meetings, women's time poverty, and extension program design that targets household heads — predominantly male in most surveyed contexts.

The economic consequences of gender-differentiated extension access are substantial. Studies documenting comparable or larger extension effects among female farmers who do receive services establish that the gender gap in extension contact is not explained by female farmers' lower returns to information — if anything, returns appear larger among women who face greater initial knowledge deficits due to historical exclusion from extension systems. Closing the gender gap in extension access therefore represents a high-return investment opportunity. Interventions shown to increase female extension access include female extension agent recruitment targets, women-specific advisory sessions and farmer groups, mobile advisory services that reduce travel constraints, and extension scheduling adapted to women's domestic time burdens.

A RESEARCH AGENDA FOR NEXT-GENERATION EVALUATION

Long-Run Income Dynamics

The most significant evidence gap in the current literature concerns long-run income dynamics. The vast majority of extension impact evaluations measure outcomes within two agricultural seasons of program delivery, capturing only immediate-term effects. Evidence from the few studies with multi-year follow-up suggests that extension impacts on income evolve substantially over time — sometimes growing as adoption deepens and learning compounds, sometimes declining as program-supported input supply is discontinued or prices adjust. Long-run follow-up studies with high-quality tracking over five or more years are a critical priority for understanding whether extension generates durable income gains or

transitory impulses.

General Equilibrium and Community-Level Effects

Most extension evaluations estimate partial equilibrium effects — the impact on directly treated farmers holding market prices and community technology stock constant. As extension programs achieve substantial penetration within communities or regions, two general equilibrium adjustments become important. First, widespread adoption may reduce output prices through localized supply increases, eroding income gains particularly for farmers who adopted early. Second, technology spillovers to non-treated farmers create positive externalities that standard evaluation designs misattribute to the program rather than the social learning process. Evaluation designs capable of capturing these effects — including saturation experiments with randomization at multiple geographic levels and structural models incorporating market price responses — are needed to enable welfare evaluation of extension programs at scale.

Adaptive Extension and Real-Time Feedback Systems

Emerging digital data infrastructure creates opportunities for adaptive extension program management that were unavailable to previous evaluation generations. Mobile-linked farmer monitoring systems can track adoption rates, input purchases, and yield outcomes in near-real time, enabling program managers to identify underperforming program components and adjust recommendations rapidly. Evaluation frameworks for adaptive extension programs require methods capable of evaluating dynamic treatment regimes — sequences of interventions responsive to prior outcomes — rather than the fixed treatment designs assumed by most experimental evaluation frameworks. Multi-arm adaptive trial designs and Bayesian updating approaches represent promising directions for this evaluation challenge.

Structural Economic Modelling

Randomized and quasi-experimental evaluation designs provide rigorous evidence on the income effects of specific extension programs in specific contexts, but have limited capacity for generalization to new contexts or counterfactual policy simulations. Structural economic models, which estimate the underlying preference and production parameters governing farmer decision-making, enable simulation of how different extension designs, commodity price environments, and complementary policy changes would affect farm income across a range of counterfactual scenarios. The combination of experimental variation for parameter identification with structural models for extrapolation represents a methodological frontier that agricultural extension evaluation has only begun to exploit.

CONCLUSION

The economic evidence on agricultural extension and advisory services, reviewed across 75 studies spanning four developing regions and three decades of research, supports a clear bottom line: well-designed and adequately resourced extension programs reliably increase farm income, with average effects in the range of 12 to 38 percent, and the range of delivery modalities capable of generating these gains has expanded significantly as digital platforms have matured. At the same time, the evidence reveals that the pathway from extension contact to income gain is neither automatic nor uniform — it runs through knowledge acquisition, behavioral change, and productivity improvement, each step mediated by input market access, credit availability, risk preferences, and social capital, meaning that extension programs designed without regard to these contextual factors will systematically underperform.

Three findings from this review deserve particular emphasis in policy discussions. First, the input complementarity finding — that extension impact is substantially larger when complementary inputs are available and affordable — implies that the most effective extension investments are those embedded in broader programs of agricultural system development, not standalone knowledge delivery initiatives. Second, the gender access finding — that female farmers are systematically excluded from extension at rates generating large foregone income gains — implies that gender equity in extension is not merely a social objective but an economic imperative. Third, the cost-effectiveness finding — that the 19-fold range in cost per income dollar generated across delivery modalities is as policy-relevant as the range in impact magnitudes — implies that extension program design decisions made without cost data are decisions made poorly.

The research agenda needed to advance evidence-based extension policy is demanding but tractable. Long-run follow-up of existing experimental cohorts, evaluation designs capable of capturing general equilibrium effects, structural models enabling policy simulation, and adaptive evaluation frameworks suited to digital extension platforms are all achievable priorities that would substantially advance the field. The persistence of more than 500 million smallholder farm households in low-income countries who stand to benefit from improved agricultural knowledge access provides a powerful rationale for accelerating this agenda. Closing the distance from knowledge to income remains among the most consequential challenges in development economics.

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