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Farmers' Awareness and Adoption of Improved Soil and Crop Management Practices: A Review

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ABSTRACT

Improved soil and crop management practices can substantially raise agricultural productivity, yet their impact depends entirely on whether farmers first become aware of them and then choose to adopt and sustain their use. This review synthesizes recent evidence on farmers' awareness and adoption of improved soil and crop management practices, drawing on global meta-analyses, systematic reviews and country-level surveys. Awareness of individual practices varies widely, from near-universal recognition of simple practices such as intercropping and crop rotation (over 90%) to substantially incomplete awareness of more technical practices such as integrated soil fertility management and biofertilizers (55–65%), with awareness itself sometimes diverging from true technical understanding. Even where awareness is high, adoption lags further behind: a global meta-analysis of 164 studies found that fewer than half of the determinants commonly believed to drive technology adoption in Sub-Saharan Africa have consistent empirical support, with access to information, land tenure security, social capital and wealth among the few robust predictors. Extension and advisory delivery mechanisms matter greatly: farmer field schools raise yields by about 13% and incomes by about 20% on average, video-based extension can raise practice-specific adoption by 22–36%, and information and communication technology (ICT)-based advisory services improve awareness in 60% and adoption in 76% of evaluated studies. Persistent barriers include limited extension reach, unequal access to mobile and digital tools by gender and farm size, weak land tenure, and a mismatch between farmers' terminology and formal practice definitions. The review concludes that closing the awareness–adoption gap requires combining credible, locally tailored information delivery with structural enablers such as credit, secure tenure and social learning networks, rather than relying on information provision alone.

INTRODUCTION

Decades of agronomic research have produced a wide array of improved soil and crop management practices — from integrated soil fertility management and conservation tillage to biofertilizers, precision nutrient application and climate-smart cropping systems — with well-documented potential to raise yields and improve resource use efficiency. Yet the productivity gains demonstrated on research stations frequently fail to materialize at scale, because farmers must first become aware that a practice exists, understand how and why it works, and then judge it worth adopting under their own resource constraints and risk environment. This gap between technical potential and realized impact is well illustrated in smallholder systems: a synthetic review of soil fertility management in semi-arid sub-Saharan Africa found that while integrated approaches can raise maize yields by 15–145%, many farmers continue to apply organic manure at a fraction of recommended rates, reflecting constraints on awareness, inputs and information rather than on agronomic knowledge alone (Kugedera et al., 2023).

Understanding why farmers do, or do not, take up

improved practices has therefore become a research field in its own right, spanning agricultural economics, extension science, rural sociology and, increasingly, digital development. This review synthesizes recent evidence on three interlinked questions: (i) how aware are farmers of improved soil and crop management practices, and does awareness translate into accurate technical understanding; (ii) what socioeconomic, institutional and psychological factors most consistently determine whether an aware farmer goes on to adopt a practice; and (iii) which extension and information delivery mechanisms are most effective at closing the gap between awareness and sustained adoption. The review closes with a discussion of persistent barriers and implications for policy and extension design.

FROM AWARENESS TO ADOPTION: A CONCEPTUAL DISTINCTION

Awareness, knowledge and adoption are conceptually distinct stages that are often conflated in casual discussion but behave quite differently in the data. Awareness refers to a farmer's recognition that a practice exists; knowledge refers to a working technical understanding of how and why it functions; and adoption refers to its actual, sustained use on the farm. A study of climate-smart agriculture in a smallholder farming population found that these three stages do not always move together: for some practices, such as rainwater harvesting and biofertilizers, farmers reported awareness that exceeded their demonstrated technical knowledge (superficial awareness), while for others, such as improved varieties and soil fertility management, technical knowledge exceeded stated awareness because farmers used different local terminology than the formal practice name (terminology mismatch). Secondary education emerged as a critical threshold, with less-educated farmers showing zero awareness of several technical practices, including conservation tillage, cover cropping, soil fertility management and water-efficient irrigation.

This distinction matters for policy: an intervention that raises stated awareness (for example, a poster campaign naming a practice) will not necessarily raise adoption if farmers do not understand the practice's mechanism or already use an equivalent method under a different name. Effective diagnosis of the awareness–adoption gap therefore requires measuring not just whether farmers have heard of a practice, but whether they understand it and have the resources to act on it.

LEVELS OF FARMER AWARENESS OF IMPROVED PRACTICES

Awareness of specific improved practices varies substantially depending on their complexity, visibility and fit with existing farming systems. In a survey of thirteen climate-smart agricultural practices among smallholder farmers, awareness ranged from 47.0% to 100%, with simple, visible practices such as intercropping (100%), crop rotation (90.8%) and agroforestry (90.3%) approaching universal recognition, while more technically framed practices such as soil fertility management (56.0%), biofertilizers (64.5%) and integrated pest management (65.0%) remained substantially less familiar (see Figure 1). The same study found that the farmer population was polarized: 54.2% of farmers reported high awareness across 10–13 practices, while 15.0% reported very low awareness of only 0–3 practices, indicating that information gaps are concentrated among a specific, identifiable subgroup rather than spread evenly across the population.

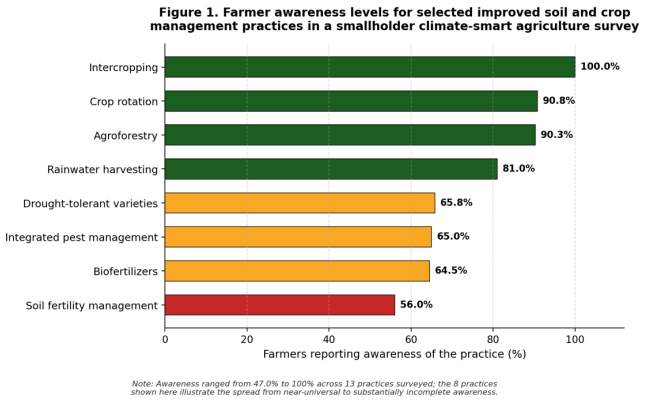

Figure 1: Farmer-reported awareness (%) of eight selected improved soil and crop management practices, illustrating the spread from near-universal recognition of simple practices to substantially incomplete awareness of more technical ones.

Similar patterns of incomplete awareness of soil-specific information are documented elsewhere. In the Mbeya Region of Tanzania, 81% and 72% of surveyed smallholder farmers reported a lack of awareness of their specific soil type and of general soil information relevant to their farmland, respectively, and this deficit was significantly associated with lower adoption of improved agricultural practices (Justine, Ocansey & Csorba, 2025). Such findings underscore that soil-specific diagnostic information — not just knowledge of practices in the abstract — is itself a binding constraint on informed decision-making.

Table 1: *Key determinants of farmers' adoption of improved agricultural practices, synthesized from meta-analyses and systematic reviews.*

Education level of household head	Positive	Improves ability to process and evaluate new information; significant in 10 of 12 studies in an Ethiopian meta-analysis	Feyisa (2020)
Land tenure / ownership security	Positive	Farmers with secure tenure are more willing to make longer-term soil investments	Arslan et al. (2022)
Access to credit	Positive	Enables purchase of inputs and adoption of capital-intensive practices	Feyisa (2020)
Wealth / asset endowment	Positive (context-specific)	Strong predictor for fertilizer adoption despite subsidies; weaker for improved seed and alternative nutrient management	Arslan et al. (2022)
Social capital, group membership and peer learning	Positive	Farmer-to-farmer learning and group membership raise the likelihood of trial and continued use	Arslan et al. (2022); Ogieriakhi & Woodward (2022)
Perceived benefit to soil health / profitability	Positive	Farmers who believe a practice benefits their specific soil and crop mix are far more likely to adopt and sustain use	Ogieriakhi & Woodward (2022)
Farm size	Positive	Adopters of soil health BMPs operate larger farms, both in area and cash receipts, than non-adopters	Shah et al. (2022)
Gender of farm decision-maker	Practice-specific	Female-headed farms showed higher adoption intensity of agri-environment-climate measures despite resource constraints	Fertő & Bojnec (2024)

DETERMINANTS OF ADOPTION

Even where awareness is present, adoption of improved practices remains far from automatic. A meta-analysis synthesizing findings from 164 published studies across Sub-Saharan Africa tested 38 determinants commonly believed to influence technology adoption and found that just over half — 20 out of 38, or 53% — lacked consistent empirical support across studies, while 18 determinants, primarily relating to information access, wealth, group membership and social capital, and land tenure, showed consistent positive associations with adoption (Arslan et al., 2022). This finding is significant because it challenges the assumption that any single, universally important barrier explains low adoption; instead, the relevant determinants are often technology- and context-specific. Table 1 summarizes the determinants for which the evidence base is strongest.

Socioeconomic and Institutional Factors

Across multiple meta-analyses, education, access to extension services, access to credit, and secure land tenure emerge as the most reliably positive predictors of adoption. A meta-analysis of 12 Ethiopian studies found that age of household head, education level, farm size, livestock holding, access to extension and credit services, cooperative membership and distance to market were all significantly associated with technology adoption, with only gender and family size failing to reach significance (Feyisa, 2020). Similarly, in the Sub-Saharan Africa-wide meta-analysis, wealth remained a significant determinant of fertilizer adoption despite decades of fertilizer subsidy programmes, though this association weakened for improved seed and alternative nutrient management technologies — suggesting that subsidy design has not adequately reached the poorest, least-resourced farmers who might benefit most (Arslan et al., 2022).

Psychological and Social Factors

Beyond resource endowments, farmers' subjective beliefs about a practice's fit with their own land strongly shape adoption decisions. A systematic review of soil conservation tillage adoption found that farmers in general value soil health, but adopters specifically believe conservation tillage benefits their particular farm and crop mix, while non-adopters often remain unconvinced of its applicability to their own conditions — even when they do not dispute the underlying scientific evidence (Ogieriakhi & Woodward, 2022). This distinction between general belief in a principle and specific belief in its local applicability helps explain why blanket information campaigns are often less effective than locally demonstrated, farm-specific evidence. Social capital compounds this effect: farmer-to-farmer learning and group membership consistently raise the likeli-

Table 2: *Reported effects of selected extension and information delivery channels on farmer awareness, technology adoption, yield and income.*

Delivery channel	Reported effect	Source
ICT-based extension (SMS, apps, video, voice) – pooled evidence	76% of 49 studies reported increased practice adoption; 60% improved awareness; 74% higher yield; 68% higher income	Mulungu, Kassie & Tschopp (2025)
Video-based extension (Digital Green model, Ethiopia)	22–36% increase in adoption of row planting, correct seed rate and urea side-application vs. traditional extension	cited in Mulungu et al. (2025)
Smartphone-based digital extension (WeChat app, China)	Significantly increased adoption of soil testing and formula fertilization (precision fertilizer technology)	Li, Zhuo, Ji & Zhu (2022)
Mobile voice/IVR agri-advisory (Direct2Farm, India)	40% of 400,000 registered farmers became active users; women, smallholders and elderly engaged least	Kansiime et al. (2019)
Farmer Field Schools (FFS), multi-country evidence	+13% agricultural yield and +20% income on average; reduced pesticide overuse	Waddington et al. (2014)

hood of both initial trial and sustained adoption (Arslan et al., 2022).

Gender Dimensions

The relationship between gender and adoption is practice- and context-specific rather than uniform. In a farm-level study of agri-environment-climate scheme adoption in Slovenia, female-headed farms showed higher adoption rates (67.2%) than male-headed farms (63.3%) and received higher subsidies per hectare, despite a persistent gender gap in land, capital and other factor endowments that typically favour men (Fertő & Bojnec, 2024). This suggests that where women farmers do have decision-making authority, they are not less inclined toward sustainable practice adoption — the more binding constraint is often unequal access to the land, credit and information that adoption requires in the first place, an issue explored further in Section 5 in the context of digital advisory access.

EXTENSION, INFORMATION AND ADVISORY SERVICES: CLOSING THE GAP

Because information access is among the few adoption determinants with strong, consistent empirical support, the design of extension and advisory delivery mechanisms is central to translating awareness into adoption. Table 2 summarizes reported outcomes from several major categories of information delivery evaluated in the recent literature.

A systematic review of 49 studies on information and communication technology (ICT)-based extension — covering mobile apps, SMS messaging, educational videos and voice-based services — found that 76% reported increased adoption of recommended practices, 60% demonstrated improved awareness, 74% showed higher yields, and 68% observed increased incomes, with success strongly dependent on well-designed messaging, adequate user training, and integration with complementary in-person support rather than technology deployment alone (Mulungu, Kassie & Tschopp, 2025). Video-mediated extension using a farmer-to-farmer peer model in Ethiopia was found to be markedly more effective than conventional extension visits, raising adoption of three recommended practices — row planting, reduced seed rate and correct urea side-application — by 22–36% across three major cereal crops.

Farmer Field Schools (FFS), a participatory, hands-on extension model, show some of the most robust average effects in the literature: a Campbell systematic review synthesizing 92 impact evaluations found that FFS participation raised agricultural yields by approximately 13% and farm income by approximately 20% on average, alongside reductions in pesticide overuse, although the strongest evidence came from short-term pilot programme evaluations rather than long-run, low-risk-of-bias studies (Waddington et al., 2014).

Mobile-based advisory services illustrate both the promise and the limits of digital delivery. An evaluation of the Direct2Farm voice and SMS advisory service in India found that 40% of its 400,000 registered farmers became active users, and the majority regarded the service as a valuable and credible information source; however, small-scale farmers, women and elderly farmers were significantly less likely to engage with the mobile service, instead preferring traditional, in-person extension approaches — a digital divide attributed to lower literacy and unequal ownership or control of mobile phones (Kansiime et al., 2019). Similarly, a smartphone-based digital extension application in China was found to significantly increase adoption of soil testing and formula fertilization, a precision nutrient management technology, though effects varied by farm production scale (Li et al., 2022). Together, this evidence indicates

that digital and ICT-based tools can meaningfully raise both awareness and adoption, but only when paired with efforts to reach farmers who are otherwise excluded by literacy, gender or infrastructure constraints.

ADOPTION OF SPECIFIC SOIL AND CROP MANAGEMENT PRACTICES

Soil Testing, Organic Amendments and Integrated Soil Fertility Management

Direct survey evidence on soil health practice adoption illustrates how adoption rates vary even among a defined menu of related practices offered to the same farmer population. In a survey of 247 Ontario farmers evaluating adoption of six soil health beneficial management practices — cover crops, crop rotation, no-till, soil testing, conservation buffers and organic amendments — soil testing had the highest adoption rate and conservation buffers the lowest, while 73% of farmers had implemented four or more of the six practices, with adoption of different practices positively correlated (Shah, Weersink & Vyn, 2022). Improving soil health was farmers' most commonly cited motivation for adoption across all six practices, ahead of purely economic considerations, and the study identified financial incentives, easily accessible information and advice, and farmer-to-farmer learning as the interventions most likely to shift non-adopters toward adoption.

Conservation Tillage and Residue Management

Conservation tillage adoption depends heavily on farmers' specific, farm-level beliefs about its suitability, as noted in Section 4.2. A systematic review identified seven key factors shaping the farmer's decision problem, spanning economic returns, land tenure arrangements (a tenant farmer favourable to conservation tillage may still not adopt if the landlord objects), risk perception, and social and institutional context, concluding that extension efforts aiming to raise adoption should focus specifically on demonstrating soil-health benefits relevant to farmers' own conditions rather than presenting generic evidence (Ogieriakhi & Woodward, 2022).

Broader Technology Adoption Patterns in Developing-Country Agriculture

At a broader scale, a meta-analysis of the empirical literature on agricultural technology adoption in the developing world found that adoption rates and their determinants are highly heterogeneous across technology types (seed, fertilizer, soil and water conservation, mechanization) and geographic contexts, cautioning against one-size-fits-all policy prescriptions and pointing instead toward technology- and context-specific diagnostic research to guide extension design (Ruzzante, Labarta & Bilton, 2021). This finding reinforces the pattern seen throughout this review: awareness, understanding and adoption of improved soil and crop management practices are shaped by an interacting bundle of technical, institutional, social and psychological factors that must be diagnosed locally rather than assumed.

BARRIERS TO ADOPTION

Synthesizing the evidence reviewed above, several recurring barriers limit the translation of awareness into sustained adoption of improved soil and crop management practices:

- Incomplete or superficial awareness: farmers may recognize a practice's name without understanding its mechanism, or may already use an equivalent practice under different local terminology, leading survey-based awareness figures to over- or under-state true readiness to adopt.
- Weak or inequitable extension reach: traditional in-person extension services often cannot reach the scale of smallholder populations, while digital alternatives systematically under-reach women, elderly and smallholder farmers due to literacy and device-access gaps.
- Insecure land tenure and limited credit access: these structural constraints reduce farmers' willingness and ability to make the medium-term investments many soil management practices require.
- Farm-specific scepticism: farmers may accept the general scientific case for a practice while doubting its applicability to their own soil, crop mix or risk environment, a distinct barrier from lack of awareness or resources.
- Fragmented, single-channel information delivery: interventions relying on one communication channel alone (e.g., SMS only) tend to underperform relative to those combining messaging with training, demonstration and peer interaction.

POLICY AND EXTENSION IMPLICATIONS

The evidence reviewed points toward several practical implications for extension design and policy. First, information campaigns should be diagnosed and tailored

at the level of individual practices rather than treated as a single undifferentiated 'awareness-raising' exercise, given the wide variation in baseline awareness (47–100%) documented across practices. Second, extension approaches that combine credible information delivery with peer learning and hands-on demonstration — as in farmer field schools and video-mediated peer extension — consistently outperform one-way information transfer alone. Third, digital and mobile advisory tools offer substantial reach and cost advantages but require deliberate design to avoid reinforcing existing gender, literacy and wealth-based exclusion from information access. Finally, because land tenure, credit access and wealth remain robust structural determinants of adoption independent of awareness, extension investments should be paired with complementary policies addressing these enabling conditions, rather than treating information provision as a sufficient intervention on its own.

CONCLUSION

Farmer awareness of improved soil and crop management practices varies widely — from near-universal recognition of simple, visible practices to substantially incomplete understanding of more technical soil fertility and integrated pest management approaches — and awareness itself does not guarantee adoption. The strongest and most consistent determinants of adoption across the global literature are access to general information and extension, secure land tenure, social capital and peer learning, and farmers' specific belief that a practice suits their own land and circumstances, rather than any single universal barrier. Extension and information delivery mechanisms that combine credible messaging with hands-on demonstration, peer interaction and locally relevant evidence — including farmer field schools, video-mediated peer extension and well-designed digital advisory services — achieve measurably larger gains in awareness, adoption, yield and income than one-way information transfer alone. Closing the persistent gap between agronomic knowledge and on-farm practice will require extension systems and policies that address structural enablers alongside information provision, and that are deliberately designed to reach the women, smallholders and lower-literacy farmers who are most often left behind by conventional and digital channels alike.

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