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Bridging the Gap a Review of Extension Approaches for Enhancing Vegetable Farmers' Knowledge and Practices

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ABSTRACT

Vegetable production is knowledge-intensive: yields, food safety, and pesticide-related health risks all depend on farmers accessing and applying up-to-date agronomic information. This review synthesizes evidence on extension approaches used to build vegetable farmers' knowledge and practices, spanning conventional group- and individual-contact methods, Farmer Field Schools (FFS), and digital or ICT-based advisory services. Evidence from Farmer Field School evaluations, mobile advisory programmes, and vegetable-specific knowledge surveys in South and Southeast Asia and West Africa shows that extension contact reliably raises farmer knowledge, but the knowledge-to-practice gap remains wide, and gains from any single approach tend to fade over time without reinforcement. The review closes with a discussion of integrated extension models and the persistent barriers that limit reach, particularly for smallholder, women, and elderly vegetable farmers.

INTRODUCTION

Agricultural extension exists to close the gap between what is scientifically known about good farming practice and what farmers actually do in the field [1]. This gap is especially consequential in vegetable production: vegetables are high-value, input-intensive crops prone to heavy pesticide use, and farmers' knowledge of Good Agricultural Practices (GAP) and integrated pest management (IPM) directly affects both crop safety and their own health [10], [11]. Because vegetable cropping cycles are short and market-facing, extension approaches that work well for staple grain crops do not always transfer directly, and a distinct body of evidence has emerged specifically around vegetable farmer knowledge and practice change.

This review examines four categories of extension approach — conventional individual and group contact methods, Farmer Field Schools, digital and ICT-based advisory services, and market-linked extension — and synthesizes what the evidence shows about their effect on vegetable farmers' knowledge, attitudes, and practices (KAP). It closes by identifying the barriers that persist even where extension contact has measurably improved knowledge.

CONVENTIONAL EXTENSION APPROACHES

Reviews of agricultural extension methods generally group conventional approaches into three broad categories [1], [6]:

- Individual contact methods: farm and home visits, one-on-one advice, and result demonstrations, which allow tailored recommendations but reach relatively few farmers per extension worker [1].
- Group contact methods: method demonstrations, field days, group meetings, and Farmer Field Schools, which trade some individualization for scale and peer learning [1], [6].
- Mass contact methods: radio, television, print media, and (increasingly) social media, which reach the

largest audiences but support only shallow engagement and limited two-way feedback [1].

A recurring finding across this literature is that no single method dominates; effectiveness depends on the complexity of the practice being promoted, the farmer's starting knowledge, and the availability of follow-up support. Simple agronomic messages (fertilizer timing, planting density) transfer reasonably well through mass and group methods, while more complex, judgment-based practices — such as diagnosing pest pressure or deciding when to withhold pesticide application — generally require sustained, hands-on engagement such as Farmer Field Schools [1], [6].

FARMER FIELD SCHOOLS FOR VEGETABLE INTEGRATED PEST MANAGEMENT

The Farmer Field School (FFS) model, built around season-long, hands-on group learning in real fields, has been the most extensively evaluated extension approach for vegetable IPM. A systematic review and meta-analysis of FFS evaluations found consistent evidence that FFS participation improves farmers' knowledge and adoption of promoted practices, along with downstream gains in production and income, although the authors caution that the rigorous impact-evaluation evidence base remains relatively small [4].

Vegetable-specific FFS evaluations reinforce this pattern. A study of urban and peri-urban vegetable producers in Cotonou, Benin, found that FFS-IPM training increased farmers' knowledge of IPM and that this knowledge was partially incorporated into production practices, although no significant reduction was observed in the type of synthetic pesticide used, illustrating that knowledge gains do not automatically translate into full practice change [3]. A related study of vegetable IPM adoption found that most tomato and cabbage growers who completed the training reached only a medium level of practice adoption (63.3% and 59.2% respectively), even though their measured knowledge levels were higher [5].

Taken together, these findings suggest FFS reliably builds knowledge but that translating knowledge into sustained practice — and keeping that practice in place over years — is a distinct challenge that one-off training does not solve [7].

Table 1: Evidence on Farmer Field School Impact for Vegetable and Related Crops

Study context	Approach evaluated	Key finding
Cotonou, Benin (urban/peri-urban vegetables)	FFS-IPM training	Increased IPM knowledge; partial adaptation into practice; no significant change in pesticide type used [3]
Multi-country systematic review (368+ evaluations screened)	FFS across crops including vegetables	Consistent gains in knowledge and practice adoption; income and yield benefits reported, but evidence base for rigorous causal inference remains small [4]
Jember, Indonesia (tomato and cabbage)	FFS-based IPM training	63.3% of tomato growers and 59.2% of cabbage growers reached only medium-level practice adoption despite improved knowledge [5]
Long-term follow-up, multiple countries	FFS-IPM, 4–8 years post-training	Farmers trained 4–8 years earlier reported 49% higher pesticide applications than those trained 1–3 years earlier, suggesting practice gains erode without reinforcement [7]

Sources: [3], [4], [5], [7].

DIGITAL AND ICT-BASED EXTENSION APPROACHES

As mobile phone penetration has grown, digital and ICT-based extension has emerged as a way to reach far more farmers than traditional field-based methods allow, at substantially lower marginal cost per farmer [2], [6]. A scoping review of technology applications in agricultural extension found that ICT tools are used across the full extension cycle, from needs diagnosis to advice delivery to feedback collection, and that the benefits are clearest for straightforward agronomic topics such as fertilizer application, planting practices, and pest management [2], [6].

A consistent caveat across this evidence is a digital divide: the same groups who are hardest to reach through conventional extension — small-scale, female, and elderly farmers — are also least likely to actively use mobile or app-based advisory services, meaning digital extension complements rather than replaces field-based methods for the most vulnerable vegetable-growing households [8].

Table 2: Evidence on Digital and ICT-Based Extension Approaches

Programme / study	Technolog	Reported outcome
Direct2Farm, India	Mobile voice/SMS advisory	40% of 400,000 registered farmers became active users; service significantly influenced uptake of new practices ($p < 0.01$); smallholders, women, and elderly farmers used it less [8]
Video-mediated extension, Ethiopia	Farmer-to-farmer video screening	22–36% increase in adoption of recommended practices (row planting, seed rate, urea application) across three staple crops, relative to traditional extension [9]
"Zhe'yang'shi" WeChat application, China	Smartphone app-based extension	Significant increase in adoption of soil testing and formula fertilization (precision nutrient management) among app users [12]
Multi-study scoping review	Mixed ICT modalities	80% of reviewed studies reported increased technology adoption from ICT interventions; two-way, multimedia formats outperformed one-way text messages [2], [6]

Sources: [2], [6], [8], [9], [12].

VEGETABLE FARMERS' KNOWLEDGE GAPS: EVIDENCE FROM THE FIELD

Direct assessments of vegetable farmers' knowledge levels illustrate why extension investment in this subsector matters. A 2025 study of 240 vegetable farmers in Rangpur district, northern Bangladesh, used Bloom's Taxonomy to classify farmers' knowledge of Good Agricultural Practices and found that half of respondents had poor GAP knowledge, with only a small fraction reaching a "good" knowledge level [10].(fig 1.)

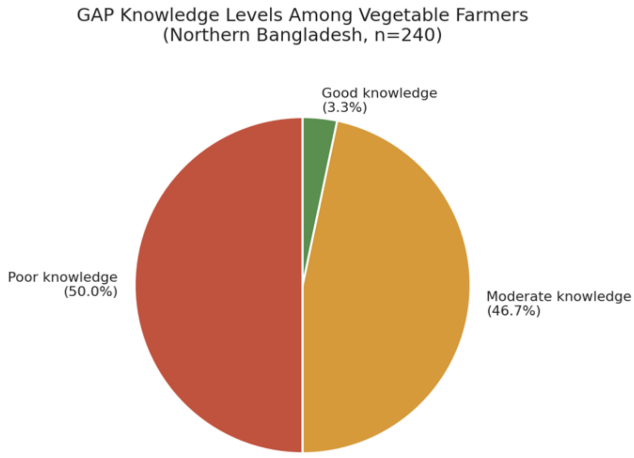

Figure 1: Distribution of GAP knowledge levels among vegetable farmers surveyed in northern Bangladesh (n = 240) [10].

The same study found that educational level, prior agricultural training, and contact with extension media were the strongest predictors of GAP knowledge, with extension media contact alone accounting for two-thirds of the variance in knowledge scores — a striking indicator of how much extension access shapes what vegetable farmers know [10]. The top-ranked problems farmers reported in applying GAP were a lack of GAP-specific training, limited understanding of GAP standards, and inadequate knowledge of integrated pest and disease management, pointing directly back to gaps in extension delivery rather than farmer unwillingness to adopt [10].

A separate Bangladesh study comparing vegetable farmers inside and outside a market-aggregation extension scheme ("LOOP", run by Digital Green in Jashore) found that farmers with structured market linkage and associated extension contact scored substantially higher on pesticide-safety knowledge, attitudes, and practices than farmers without that linkage [11].(fig 2.)

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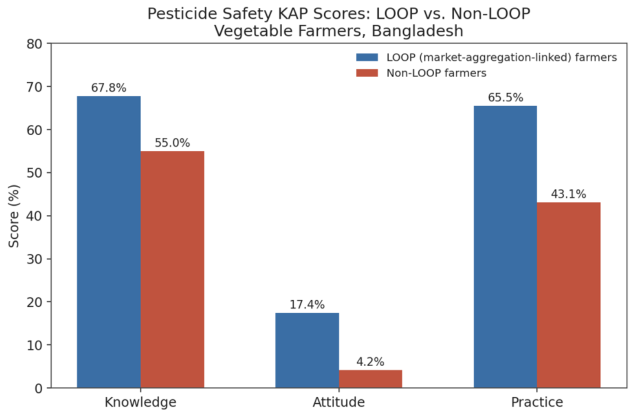

Figure 2: Pesticide safety knowledge, attitude, and practice (KAP) scores for vegetable farmers with and without market-aggregation-linked extension contact, Jashore, Bangladesh [11].

Notably, even LOOP-linked farmers' attitude scores remained low in absolute terms (17.4%), despite comparatively higher knowledge and practice scores, reinforcing a theme seen in the FFS literature: knowledge gains transfer unevenly into attitudes and practice, and attitude change in particular appears to be the hardest outcome to shift through extension contact alone [11].

FACTORS INFLUENCING KNOWLEDGE AND ADOPTION

Across the reviewed studies, several factors consistently predict whether vegetable farmers gain and retain extension-delivered knowledge:

- Education and prior training: formal education and previous agricultural training experience are consistently associated with higher GAP and IPM knowledge scores [10].
- Extension contact intensity and recency: frequency of contact with extension media is often the single strongest predictor of knowledge, but the benefit of any one contact fades over multi-year horizons without reinforcement [7], [10].
- Market linkage: farmers connected to structured market-aggregation or buyer-quality schemes show higher knowledge and practice scores, likely because the schemes create a direct incentive to demonstrate compliant practices [11].
- Gender, age, and scale: smallholder, women, and elderly farmers are consistently underserved by both traditional field-based extension (due to workload and mobility constraints) and newer digital advisory services (due to phone access, literacy, and digital confidence gaps) [8].

THE KNOWLEDGE–PRACTICE GAP

A theme that recurs across nearly every study reviewed here is that improved knowledge does not reliably or fully translate into changed practice. In Benin, FFS-trained vegetable farmers gained IPM knowledge without a corresponding drop in synthetic pesticide use [3]. In Indonesia, most FFS-trained tomato and cabbage growers plateaued at medium practice adoption despite stronger knowledge scores [5]. In multi-country long-term follow-up, pesticide applications among FFS-trained vegetable farmers rose again 4–8 years after training, suggesting that even successful practice change is not durable without ongoing reinforcement [7]. In Bangladesh, LOOP-linked farmers with comparatively strong knowledge and practice scores still reported very low positive attitudes toward safe pesticide use, indicating that the underlying beliefs driving behaviour had not shifted to match what farmers now knew [11].

This pattern suggests that extension programming aimed at vegetable farmers needs explicit mechanisms for practice reinforcement and attitude change — not just initial knowledge transfer — if it is to produce durable improvements in pesticide safety and GAP compliance [7], [11].

TOWARDS INTEGRATED EXTENSION MODELS

The evidence points toward combining approaches rather than relying on any single extension channel. A workable model for vegetable extension emerging from this literature would pair season-long, hands-on Farmer Field School training (to build practical judgment around pest identification and safe pesticide use) with ongoing mobile or app-based advisory contact (to reinforce timing-sensitive messages between seasons) and market-linked incentives (to sustain motivation for compliant practice after formal training ends) [2], [4], [11]. Participatory approaches that treat farmers as co-generators of knowledge, rather than passive recipients, are also identified as improving both engagement and the contextual fit of recommended practices [1], [6].

DISCUSSION AND RESEARCH GAPS

The literature on vegetable-specific extension is smaller and more geographically concentrated (South and Southeast Asia, West Africa) than the broader agricultural extension literature, and rigorous causal impact evaluations remain scarce relative to descriptive knowledge-and-practice surveys [4], [10]. Long-term follow-up studies are particularly rare, even though the limited evidence available suggests that practice gains from training can erode within less than a decade [7]. Digital extension research also remains skewed toward staple grain crops and general agronomic messages, leaving open questions about how well ICT-based approaches perform for the more judgment-intensive, pest-and-safety-focused knowledge that vegetable production requires [2], [6]. Finally, very few studies directly measure attitude change as a distinct outcome from knowledge and practice, despite evidence that attitude may be the most resistant of the three to shift through extension contact alone [11].

CONCLUSION

Extension approaches for vegetable farmers span a spectrum from individual farm visits to Farmer Field Schools to mobile and app-based advisory services, and the evidence reviewed here shows that each can measurably raise farmer knowledge. The harder and less-solved problem is converting that knowledge into sustained, correct field practice and genuinely shifted attitudes, particularly around pesticide safety. Programmes that combine hands-on, season-long training with ongoing digital reinforcement and market-linked incentives show the most promise for closing this gap, but they must be deliberately designed to reach smallholder, women, and elderly vegetable farmers, who remain underserved by both traditional and digital extension channels alike.

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