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Farmers' Knowledge and Adoption Behaviour Towards Scientific Vegetable Cultivation Practices: A Review

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ABSTRACT

Scientific vegetable cultivation practices — including recommended varieties, soil testing, balanced fertilization, integrated pest management (IPM), good agricultural practices (GAP), safe pesticide handling and protected cultivation — have well-documented potential to raise yield, quality and farm income. Yet the productivity gains demonstrated on research stations depend on farmers first acquiring accurate technical knowledge and then translating that knowledge into sustained field practice, a transition that is frequently incomplete. This review synthesizes recent farm-level evidence on vegetable growers' knowledge and adoption behaviour across South Asia and East Africa. Across studies, average knowledge of recommended vegetable cultivation technologies reaches 74.72% among Tamil Nadu vegetable growers, yet overall adoption trails at 55.27%, with technically demanding, input-dependent practices such as soil testing, growth regulator use and foliar spraying adopted by only 40–48% of farmers despite comparable awareness. This knowledge–practice gap recurs across contexts: only 37% of vegetable growers in Lamjung, Nepal, met the threshold for integrated pest management adoption despite widespread awareness of pesticide-related risks; only 24.42% of Bangladeshi vegetable farmers reached the highest, most independent level of good-agricultural-practice application; and in Kenya, sufficient knowledge of agricultural biologicals did not reliably translate into their use. Training participation, extension contact, farming experience, education and access to complementary inputs and credit consistently emerge as the strongest predictors of translating knowledge into practice, while the gap is narrowest for low-cost, skill-based practices and widest for capital- or input-dependent technologies. The review concludes that closing the knowledge–practice gap in vegetable cultivation requires extension and training models that move beyond information delivery to build practical, hands-on competence, paired with reliable access to the inputs, credit and market linkages that input-dependent scientific practices require.

INTRODUCTION

Vegetable production has become one of the fastest-growing and most remunerative segments of global agriculture, driven by rising urban demand, nutritional awareness and the comparatively high value-per-hectare that vegetable crops generate relative to staple cereals. Realizing this economic potential, however, depends on farmers moving away from age-old, low-input cultivation methods toward a wider set of scientific practices — recommended varieties and hybrids, soil testing and balanced nutrient application, integrated pest and disease management, safe pesticide handling, appropriate irrigation scheduling, and, increasingly, protected and high-tech cultivation systems (Ahmed et al., 2024). Because these scientific practices are often more technical, input-dependent and management-sensitive than traditional methods, the process by which a farmer moves from first hearing about a practice, to understanding it, to actually and consistently applying it in the field is neither automatic nor uniform.

A growing body of farm-level research has begun to disentangle these stages by directly measuring both farmers' technical knowledge and their actual field-level adoption of recommended vegetable cultivation practices, rather than assuming that one implies the other. This distinction matters for policy and extension design: a farmer who knows that soil testing improves fertilizer efficiency but does not adopt it faces a different constraint than one who has never heard of soil testing at all, and the two situations call for different interventions. This review synthesizes this farm-level evidence to address three questions: (i) how large is the gap between farmers' knowledge and their actual adoption of scientific vegetable cultivation practices, and does it vary by practice type; (ii) which specific practices show the widest knowledge–practice gaps, and why; and (iii) which farmer, household and institutional factors most consistently explain successful translation of knowledge into sustained adoption. The review closes with implications for extension and training design in vegetable-producing regions.

FROM TRADITIONAL TO SCIENTIFIC VEGETABLE CULTIVATION

Modern vegetable cultivation spans a continuum from simple agronomic refinements to highly technical, capital-intensive systems. A comprehensive review of this transition traces the journey from traditional, open-field, soil-based cultivation toward soilless culture systems, sustainable substrates such as biochar and coir, advanced greenhouse environmental controls, precision fertilization, integrated pest management, and the emerging integration of drones, robotics and digital monitoring technologies (Ahmed et al., 2024). This widening technical range is important context for interpreting adoption evidence: a single 'scientific vegetable cultivation' label in practice covers everything from low-cost, skill-based refinements (correct transplanting depth, timely weeding) to high-capital infrastructure (protected cultivation structures, fertigation systems), and, as later sections show, farmers' knowledge-to-adoption translation differs sharply across this range.

THE KNOWLEDGE–ADOPTION GAP: EVIDENCE ACROSS CONTEXTS

Direct, practice-level comparisons of what farmers know versus what they do provide the clearest evidence of a persistent gap between technical understanding and field application. In a study of 90 vegetable growers in Chellampatti block, Tamil Nadu, India, average farmer knowledge of recommended vegetable cultivation technologies reached 74.72%, with practices such as correct transplanting method, use of recommended varieties and high-yielding varieties (HYVs), fertilizer application, weed management, mulching and seed treatment known by 75–90% of respondents. Overall adoption, however, reached only 55.27% — nearly 20 percentage points below the knowledge level — and several technically demanding, input-dependent practices, including soil testing, soil health card recommendations, growth regulator use, mulching, foliar spray application and plant protection measures, showed adoption rates of only 40–48% despite comparable farmer awareness (Janaki Rani, 2020). Figure 1 situates this finding alongside comparable adoption-level evidence from other vegetable-growing contexts.

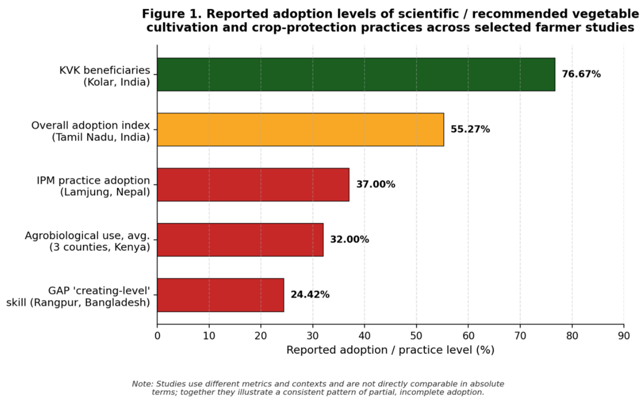

Figure 1: Reported adoption levels of scientific or recommended vegetable cultivation and crop-protection practices across five farmer studies. Because studies use different metrics and contexts, the values are not directly comparable in absolute terms, but together they illustrate a consistent pattern of partial, incomplete adoption even where farmers are reasonably informed.

This pattern of incomplete translation from knowledge to practice recurs across very different vegetable-growing contexts, as summarized in Table 1. In Lamjung district, Nepal, a study of 100 vegetable-growing farmers found that although training, education and extension contact were widely recognized as important, only 37% of respondents met the threshold for integrated pest management (IPM) adoption, defined as compliance with at least 7 of 10 recom-

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Table 1: *Knowledge and adoption findings for scientific vegetable cultivation and crop-protection practices across selected farmer studies.*

Study / location	Knowledge / awareness finding	Adoption / practice finding
Vegetable growers, Tamil Nadu, India (Janaki Rani, 2020)	Average knowledge of recommended technologies: 74.72%; transplanting method, variety/HYV, fertilizer application, weed management, mulching and seed treatment known by 75–90% of farmers	Overall adoption: 55.27%; soil testing, soil health card recommendations, growth regulators, mulching, foliar spray and plant protection measures had low adoption (40–48%) despite being known
Vegetable growers, Lamjung, Nepal (Shrestha et al., 2024)	Not separately measured; training, education and extension contact identified as key knowledge drivers	Only 37% of farmers met the threshold for IPM adoption; selective pesticide use most common (54%), record-keeping and threshold-based action least common
Vegetable growers, Chitwan, Nepal (Rijal et al., 2018)	Substantial gaps in knowledge of pesticide safety, re-entry intervals and protective equipment use	Majority of farmers used partial or no personal protective equipment when applying pesticides despite awareness of associated risks
Vegetable farmers, Rangpur, Bangladesh (Sheheli et al., 2025)	Farmers showed basic understanding of GAP concepts (remembering/understanding levels of Bloom's taxonomy relatively strong)	Practical application weakened at higher cognitive levels; the 'creating' (independent adaptation) level reached only 24.42% of farmers
Smallholder farmers, 3 counties, Kenya (Mweke et al., 2025)	Only 18–47% of farmers were classified as knowledgeable about agrobiologicals, varying by county; over 70% had received no formal training	18–46% used agrobiologicals in practice; sufficient knowledge did not reliably translate into use

mended IPM standards; selective pesticide use was comparatively common (54%), while more knowledge-intensive practices such as systematic record-keeping and threshold-based action remained far less adopted (Shrestha et al., 2024). In Rangpur district, Bangladesh, an assessment of 240 vegetable farmers' knowledge of good agricultural practices (GAP) using a Bloom's-taxonomy-based framework found that farmers performed reasonably well at the foundational 'remembering' and 'understanding' cognitive levels, but performance fell sharply at higher, more practice-oriented levels, with only 24.42% of farmers reaching the 'creating' level associated with independent adaptation of GAP to their own farm conditions (Sheheli et al., 2025).

A parallel pattern appears outside strict knowledge–adoption comparisons but reinforces the same underlying dynamic. In Chitwan, Nepal, a study of vegetable growers' pesticide-related knowledge and practice found that although farmers were broadly aware of pesticide hazards, the majority used only partial or no personal protective equipment when spraying, indicating that safety knowledge alone did not ensure safe practice (Rijal et al., 2018). In three counties in Kenya, a knowledge, attitude and practice (KAP) analysis of agricultural biologicals — an increasingly promoted alternative to chemical pesticides in vegetable and other cropping systems — found that only 18–47% of farmers were classified as knowledgeable, and, critically, that sufficient knowledge did not reliably translate into increased use, with actual practice rates (18–46%) tracking closely with, rather than exceeding, knowledge levels (Mweke et al., 2025). This finding is particularly instructive: it demonstrates that raising knowledge is a necessary but not sufficient condition for adoption, since farmers who understood a practice still frequently judged it ineffective or inaccessible.

A CONCEPTUAL LENS: AWARENESS, KNOWLEDGE AND ADOPTION AS DISTINCT STAGES

Recent research has proposed disaggregating farmer cognition into three distinct, empirically measurable levels — awareness (having heard of a practice), knowledge (knowing how to implement it), and understanding of underlying principles (comprehending why it works) — arguing that this three-level framework, grounded in Bloom's revised taxonomy, provides a more nuanced diagnostic than the simple binary awareness-or-adoption measures common in agricultural research. Applying this framework to 400 smallholder farmers across 13 climate-smart practices found that awareness and knowledge frequently diverge in opposite directions depending on the practice: for some practices, awareness exceeds knowledge (farmers have heard the name but cannot implement it correctly), while for others, farmers demonstrate practical knowledge without recognizing the formal terminology (Ogutu & Cavane, 2026). This finding is directly relevant to vegetable cultivation: the Bangladesh GAP evidence discussed above (Section 3) reflects exactly

Table 2: *Factors associated with successful translation of vegetable-cultivation knowledge into field-level adoption, drawn from farm-level studies.*

Determinant	Reported association with knowledge / adoption	Source
Training / participation in IPM or GAP programmes	Greater participation in training significantly increased the probability of IPM adoption in the binary logit model	Shrestha et al. (2024)
Education level	Positive correlation with attitude and practice of GAP (r = 0.598); farmers with lower education adopted professional pest-management knowledge less readily	Sheheli et al. (2025); Shrestha et al. (2024)
Extension contact	Strongest correlate of positive GAP attitude among factors tested (r = 0.621); increased contact with extension agents significantly raised IPM adoption	Sheheli et al. (2025); Shrestha et al. (2024)
Farming / vegetable cultivation experience	Positively related to likelihood of IPM adoption; more experience provides more crop- and farm-specific information	Adoption status of IPM, Lamjung (Shrestha et al., 2024)
Off-farm income / additional income sources	Farmers with non-agricultural income sources were more likely to participate in IPM practices	Shrestha et al. (2024)
Years in farming (tenure)	Positively correlated with knowledge of agrobiologicals, but not significantly with attitude or actual practice — knowledge gain alone did not ensure use	Mweke et al. (2025)
Farm size / land ownership	Larger landholdings provide space for experimentation with new practices and are associated with higher adoption	Shrestha et al. (2024)
General information access (vs. narrow, single-practice messaging)	General information access was a more consistent predictor of technology adoption across studies than narrowly targeted messaging	Arslan et al. (2022)

this pattern, with farmers strong at recognition-level cognition but weak at application and creation — underscoring that a single-question survey item (‘Have you heard of GAP?’) would substantially overstate farmers’ practical readiness to adopt.

DETERMINANTS OF SUCCESSFUL KNOWLEDGE-TO-PRACTICE TRANSLATION

Across the studies reviewed, several farmer- and household-level factors consistently distinguish those who translate knowledge into sustained adoption from those who do not; these are summarized in Table 2.

Training and extension contact emerge as the most consistently significant determinants. In the Nepal IPM study, a binary logit model found that greater participation in training, higher education levels and increased contact with extension agents were all significant positive predictors of adoption, while the easy availability of chemical pesticides and the lack of accessible biopesticides were identified as the principal structural constraints limiting adoption even among informed farmers (Shrestha et al., 2024). In the Bangladesh GAP study, extension contact showed the strongest correlation with positive farmer attitude among all factors tested (r = 0.621), ahead of education (r = 0.598) and training experience (r = 0.491), suggesting that sustained relational contact with extension personnel may do more to shift farmer disposition than credentialed education alone (Sheheli et al., 2025).

Structural and resource constraints also shape the knowledge–practice gap independently of farmer motivation. The Bangladesh study identified pest and disease pressure, farmer inexperience, resource and financial limitations, the cost of record-keeping, and weak market incentives for GAP-certified produce as major obstacles even among farmers who valued the food-safety and environmental benefits of GAP in principle (Sheheli et al., 2025). This mirrors the finding from Kenya that low effectiveness perception and limited training, rather than knowledge deficits alone, restrained agrobiological adoption (Mweke et al., 2025), and is consistent with wider evidence that a lack of soil-specific diagnostic information constrains adoption of improved practices generally among smallholder farmers, as documented among smallholders in the Mbeya Region of Tanzania, where a majority of farmers lacked basic awareness of their own soil type and this deficit was significantly associated with lower adoption of improved agricultural practices (Justine, Ocansey & Csorba, 2025).

THE ROLE OF EXTENSION DELIVERY FORMAT

Because passive information provision appears insufficient to close the knowledge–practice gap, the format through which knowledge is delivered matters greatly. Institutional, hands-on extension models targeted specifically at horticultural producers provide some of the clearest evidence on this point. In Kolar district, India, farmers who received training, front-line demonstrations and on-farm testing through the Krishi Vigyan Kendra (KVK) system achieved high-to-medium adoption of improved horticultural technologies at a rate of 76.67%, compared with 57.33% among non-beneficiary farmers (Kumar, Reddy & Shashidhar, 2024) — the highest adoption level among the studies compared in Figure 1, and markedly above the knowledge-based, less hands-on interventions reviewed elsewhere in this paper. Similarly, a study of 274 tomato and cucumber greenhouse farm households in Beijing, China, found that Farmer Field School (FFS) participation significantly increased both cognition and adoption of new agricultural technologies, though the effect varied by technology type: simple innovations such as new varieties diffused relatively easily, while capital-intensive, facility-based technologies proved considerably harder to extend, requiring more sustained engagement (Cai, Hu & Hong, 2022).

This pattern is corroborated by a broader scoping review of 54 studies on technology-enabled agricultural extension, which found that the majority (64.8%) reported positive knowledge or adoption outcomes, and that agricultural technology (the innovation) and educational technology (the delivery method) work best in combination — the productivity benefit of a given vegetable cultivation practice is realized more fully when paired with an effective, often participatory, pedagogical method rather than one-way information transfer (Xu et al., 2023). A systematic review of farmer field schools worldwide similarly found that FFS participation raised agricultural yields by approximately 13% and farm income by approximately 20% on average, evidence broadly consistent with the hands-on, demonstration-based extension models shown here to narrow the knowledge–practice gap most effectively in vegetable systems specifically (Waddington et al., 2014).

DISCUSSION: WHY THE GAP PERSISTS AND HOW TO CLOSE IT

Synthesizing the evidence reviewed, the knowledge–practice gap in scientific vegetable cultivation is neither random nor uniform: it is narrowest for low-cost, skill-based practices that depend mainly on farmer technique and effort (correct transplanting, timely weeding, seed treatment), and widest for practices that require specialized inputs, testing infrastructure, capital or reliable market incentives (soil testing, bio-pesticides, protected cultivation, GAP certification). This pattern held consistently across India, Nepal, Bangladesh and Kenya, and across crop-management domains ranging from nutrient management to pest control to food-safety practice, suggesting it reflects a structural feature of scientific vegetable cultivation adoption rather than a artifact specific to any one country or survey instrument (Ruzzante, Labarta & Bilton, 2021).

Several practical implications follow. First, knowledge-focused interventions (information campaigns, one-off training sessions) are necessary but insufficient on their own to raise adoption of input-dependent scientific practices; they must be paired with reliable input supply, affordable credit and, where relevant, market incentives that reward the adoption of practices such as GAP certification or IPM. Second, hands-on, demonstration-based extension formats — front-line demonstrations, farmer field schools — consistently outperform passive information delivery in translating knowledge into sustained practice, and should be prioritized specifically for the more technically demanding practices where the knowledge–practice gap is widest. Third, diagnostic tools that separately measure awareness, knowledge and practical understanding, rather than relying on a single adoption indicator, provide extension planners with a more precise picture of where farmers are stalling in the knowledge-to-practice pipeline, enabling better-targeted interventions (Ogutu & Cavane, 2026). Finally, sustained extension contact appears to matter more than one-off educational credentials in shifting farmer attitude and practice, reinforcing the value of continuous, relationship-based extension models over episodic information delivery.

These findings suggest several concrete priorities for programmes seeking to raise adoption of scientific vegetable cultivation practices:

● Differentiate extension intensity by practice type: light-touch information delivery may suffice for low-cost, skill-based practices, but capital- or input-dependent practices require sustained, hands-on engagement.

● Pair training with guaranteed access to the specific inputs being promoted (bio-pesticides, soil-testing services, certified seed), since availability constraints —

not knowledge gaps — were repeatedly cited as binding barriers.

- Prioritize demonstration-based formats (front-line demonstrations, farmer field schools) over lecture-based training for practices showing the widest knowledge–practice gaps.
- Measure awareness, knowledge and practice as distinct indicators in monitoring and evaluation, rather than a single composite adoption score, to correctly diagnose where farmers are stalling.
- Invest in sustained, relationship-based extension contact rather than one-off campaigns, given its consistently strong association with positive farmer attitude and practice change.

CONCLUSION

Farmers engaged in vegetable cultivation across the contexts reviewed here are, on average, reasonably well informed about recommended scientific practices, with knowledge levels often exceeding 70%. Yet actual field-level adoption consistently lags behind knowledge by a wide and practice-dependent margin, ranging from a modest gap for low-cost agronomic refinements to a substantial gap — often 30 percentage points or more — for input-dependent, technically demanding practices such as soil testing, integrated pest management, good agricultural practices and biological pest control. This gap is best explained not by insufficient information provision but by a combination of limited hands-on training, constrained access to specialized inputs and credit, and extension delivery formats that inform without building practical competence. Closing the gap between what vegetable farmers know and what they practice will require extension systems that move decisively beyond information transfer toward sustained, demonstration-based skill-building, integrated with the input supply, credit and market-incentive structures that scientific vegetable cultivation practices depend on.

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