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Understanding the Knowledge Gap in Vegetable Production Practices Implications for Agricultural Extension- a Review

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ABSTRACT

Farm-level surveys consistently document that vegetable growers hold incomplete knowledge of improved production technologies, with "medium" knowledge the most common outcome and true mastery rare. This review moves beyond documenting that gap to ask a more operational question: what does the pattern of knowledge gaps imply for how agricultural extension systems should be designed and resourced? Drawing on vegetable-specific knowledge surveys alongside the extension-systems literature on worker-to-farmer ratios, training needs assessment, and digital extension delivery, the review finds that persistent knowledge gaps are not simply an information problem but also a capacity problem: extension systems in the countries where these gaps are largest are also the most understaffed relative to international benchmarks. The review proposes a framework linking the type of gap identified — awareness, knowledge, or adoption — to a differentiated extension response, and highlights training needs assessment and gender-responsive design as under-used but well-evidenced tools for targeting scarce extension resources more effectively.

INTRODUCTION

Documenting that vegetable growers do not fully know recommended production practices is now a well-established line of research, replicated across Good Agricultural Practices, integrated pest management, protected cultivation, and irrigation technology in multiple countries. What is less often addressed directly is what this evidence should mean for the extension systems responsible for closing that gap. A knowledge-gap finding is only useful to policy if it can be translated into a specific extension response — more staff, different training content, a different delivery channel, or a different diagnostic approach — and the literature on extension system capacity and training needs assessment offers tools for making that translation explicit.

This review synthesizes both literatures together. It first summarizes the pattern of documented knowledge gaps in vegetable production, then turns to the structural and methodological question of how extension systems are, and could be, designed to respond to that pattern — covering extension workforce capacity, training needs assessment methodology, digital delivery, and gender-responsive design.

THE KNOWLEDGE GAP: WHAT THE EVIDENCE SHOWS

Across multiple independent studies, vegetable growers' knowledge of improved production technologies clusters in the "medium" category rather than at the "high" end associated with full technical mastery. A study of vegetable growers in Tamil Nadu found average knowledge of recommended cultivation technologies at 74.72%, but overall adoption of only 55.27% — a substantial knowledge-to-adoption gap [1]. Good Agricultural Practices (GAP) surveys in Bangladesh found half of vegetable farmers in one district had poor GAP knowledge [2], while a separate district found 56.7% at only medium awareness alongside 65.0% with low adoption [3]. The specific technologies with the largest documented gaps are consistently those requiring diagnostic judgment — integrated pest management, seed treatment, and irrigation timing — rather than fixed-rule practices such as recommended varieties or fertilizer dose [1].

This pattern is now well replicated and is treated here as the starting evidence base rather than the primary focus of this review; the remaining sections examine what this pattern implies for extension system design.

WHY KNOWLEDGE GAPS PERSIST: STRUCTURAL CONSTRAINTS IN EXTENSION SYSTEMS

One explanation for persistent knowledge gaps that receives less attention than farmer-level factors is simple capacity: many public extension systems, particularly in the countries where vegetable knowledge-gap studies are concentrated, are severely understaffed relative to internationally recommended benchmarks. The Food and Agriculture Organization recommends an extension agent-to-farmer ratio of approximately 1:800 [4]. Actual ratios in much of South Asia and Sub-Saharan Africa fall well short of this benchmark.

A bibliometric review of ICT-based extension and advisory services research corroborates this capacity gap for India specifically, finding public extension service providers cover an average of roughly 1,156 operational farm holdings each — a workload that makes the kind of intensive, hands-on, judgment-building training documented as most effective for closing knowledge gaps (see Section 2) difficult to deliver at scale through conventional staffing models alone [7]. A qualitative study of extension personnel in Central Malawi reported staff shortages, poor mobility due to unreliable transport, and heavy workloads on remaining staff as recurring, self-reported barriers to effective service delivery, directly corroborating the ratio data with frontline experience [8].

TRAINING NEEDS ASSESSMENT (TNA) AS A DIAGNOSTIC TOOL

Given capacity constraints, extension systems cannot train every farmer on every technology equally; prioritization is unavoidable. Training Needs Assessment (TNA) is the extension-research method most directly suited to this prioritization problem: it identifies the gap between farmers' current knowledge and skills and the level required, and uses that gap — rather than assumption or convenience — to set training content and priority [9]. The Borich needs-assessment model, one of the most widely used TNA approaches, weights training priority by combining a competency's importance with the size of the current knowledge deficit, so that a competency with both high importance and a large gap is prioritized over one that is important but already well known.

Table 1: Extension Worker-to-Farmer Ratios: Selected Countries and Benchmarks

Country / Context	Ratio (farmers per extension worker)	Notes
China / Vietnam	~1:280	Among the most favourable ratios documented in the literature
FAO recommended benchmark	1:800	Widely cited international guideline [4]
India (national guideline, irrigated areas)	1:1,100	Guideline is less strict for rainfed (1:750) and hilly areas (1:400) [5]
Kenya (national average)	1:1,000	Extension recruitment paused for extended periods (1986–2006) [6]
India (actual, public extension system)	1:1,156–1,162	Only ~0.12 million extension professionals nationally, versus 7.13 million in China [5], [7]
Kenya (county level, worst case)	1:2,000	More than double the FAO benchmark [6]

Sources: [4], [5], [6], [7].

Case: Farm Women's Training Needs in Jhansi District, India

A 2026 TNA study of 120 farm women in Jhansi district, India, found that 73.34% fell into the medium training-need category overall, with the highest-priority needs identified in crop storage and cattle production, followed closely by weed control and improved crop varieties. The study also found that psychological factors — particularly scientific orientation and risk orientation — predicted training need more strongly than most socio-economic factors such as landholding or income, suggesting that receptiveness to training, not just formal circumstance, should inform how extension content is pitched [10].

Case: Distinguishing Information Need from Training Need, Oyo State, Nigeria

A particularly instructive TNA finding comes from a study of women vegetable farmers in Akinyele, Oyo State, Nigeria, focused on organic agriculture. The study found a low information need (57.5% of respondents), meaning most women already felt reasonably informed about organic practices in general terms, but a high training need (59.2%), meaning most still lacked the practical skill to apply that information correctly — alongside an unfavourable overall perception of organic agricultural practices (51.7%) [11].

This distinction matters directly for extension design: it shows that "information need" and "training need" are not interchangeable, and that a farmer can feel adequately informed in general while still lacking the specific, practical skill to execute a technology correctly — which is consistent with the knowledge-versus-adoption distinction documented throughout the vegetable-specific literature in Section 2. An extension response built only around information dissemination (leaflets, radio messages, general awareness campaigns) would likely under-serve this population; what the evidence calls for instead is hands-on, skill-building training.

DIGITAL EXTENSION AS A PARTIAL RESPONSE TO CAPACITY CONSTRAINTS

Given the scale of the staffing gap documented in Section 3, digital and ICT-based extension delivery is frequently proposed as a way to extend limited extension capacity further. A study of extension practitioners in southwestern Nigeria found meaningful use of ICT tools (mobile phones, radio, and increasingly internet-based platforms) for specific extension delivery functions among both public and non-public extension organisations, though utilization varied by organisational capacity and practitioner experience [12]. A 2025 bibliometric analysis of over 500 published studies on ICT-based extension and advisory services found this to be a rapidly growing research field globally, with China, India, and a cluster of Sub-Saharan African countries as leading contributors — broadly the same countries where the extension-capacity gaps documented in Table 1 are most severe, suggesting research attention is at least directionally aligned with where the need is greatest [7].

However, digital delivery is best understood as extending reach for content that can be conveyed through information transfer, rather than fully substituting for the hands-on, diagnostic training that Section 2 identifies as most needed for judgment-intensive practices like IPM and seed treatment. The Malawi study specifically recommended integrating mobile phone and media tools to address the extensionist-farmer ratio problem, while simultaneously calling for expanded in-person capacity — treating digital delivery as a complement to, not a replacement for, additional extension staffing [8].

GENDER-RESPONSIVE EXTENSION DESIGN

Both TNA case studies reviewed in Section 4 focus specifically on women farmers, which is not incidental: women make up a substantial share of the vegetable-farming workforce in the regions studied throughout this review, yet the wider extension literature consistently documents that women farmers face particular barriers in accessing formal extension contact, including mobility constraints, time poverty from combined farm and household responsibilities, and extension systems historically staffed and designed around male farmer norms [10], [11]. The Jhansi study's finding that psychological readiness factors predicted training need better than socio-economic status further suggests that gender-responsive extension design should attend to how training is framed and delivered, not only whether women are formally included as participants [10].

A FRAMEWORK FOR EXTENSION RESPONSE BY GAP TYPE

Synthesizing Sections 2 through 6, this review proposes distinguishing three related but operationally distinct gaps, each calling for a different primary extension response:

The evidence reviewed here suggests that vegetable extension challenges frequently sit at the boundary between the second and third gap types — farmers often have partial knowledge but still fail to adopt — which implies that extension investment focused purely on more information delivery, without complementary investment in service access and input availability, is likely to show diminishing returns.

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Table 2: Matching Extension Response to Gap Type

Gap type	What it looks like	Primary extension response
Awareness gap	Farmer does not know a technology or practice exists at all	Mass communication: radio, print, SMS, farmer group meetings, basic information campaigns
Knowledge gap	Farmer is aware of the technology but cannot correctly judge when or how to apply it (e.g., diagnosing pest pressure, timing irrigation)	Hands-on, diagnostic training: Farmer Field Schools, demonstration plots, Digital Farmer Field Schools, structured TNA-driven curricula
Adoption gap	Farmer has adequate knowledge but does not apply it in practice	Address non-knowledge barriers directly: input access, cost-sharing, service infrastructure (e.g., soil testing labs), market or institutional incentives

BARRIERS TO EFFECTIVE EXTENSION DELIVERY

• **Workforce capacity:** extension worker-to-farmer ratios in the countries with the largest documented vegetable knowledge gaps fall well short of the FAO-recommended benchmark, limiting how much hands-on, diagnostic training can realistically be delivered [4], [5], [7].

• **Funding:** public extension investment has been reported to stagnate at a small fraction of agricultural GDP in some of the countries studied, constraining both staffing and programme scope [5].

• **Mobility and logistics:** unreliable transportation for extension staff was directly cited as a leading barrier to service delivery in the Malawi case study, independent of staffing numbers alone [8].

• **Underuse of diagnostic tools:** despite the demonstrated value of Training Needs Assessment in the Jhansi and Oyo State studies, TNA remains a comparatively underused planning step relative to how often extension content is designed around convention or assumption rather than measured gaps [9], [10], [11].

• **One-size-fits-all delivery:** treating awareness, knowledge, and adoption gaps as the same problem risks applying mass-communication solutions to what are actually hands-on skill-building or input-access problems, and vice versa.

DISCUSSION AND RESEARCH GAPS

The literatures reviewed here — vegetable-specific knowledge surveys and the broader extension-systems literature — have historically been published somewhat separately, and few studies explicitly connect a documented vegetable knowledge gap to an extension capacity or training-needs diagnosis in the same research design. Future research combining vegetable-specific KAP (knowledge-attitude-practice) surveys with a formal TNA and an extension-capacity assessment in the same study site would allow a much more direct test of the framework proposed in Section 7. The extension worker-to-farmer ratio data compiled in Table 1 also draws on sources using different measurement methods and years, and should be read as an indicative rather than a precisely comparable cross-country dataset. Finally, evidence on the cost-effectiveness of TNA-driven, targeted extension programming compared to conventional, non-targeted extension delivery remains thin and would strengthen the policy case for wider TNA adoption.

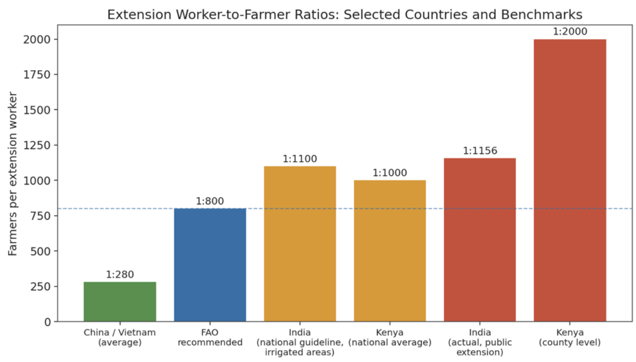

Figure 1: Extension worker-to-farmer ratios across selected countries and benchmarks. Lower values indicate more extension capacity per farmer.

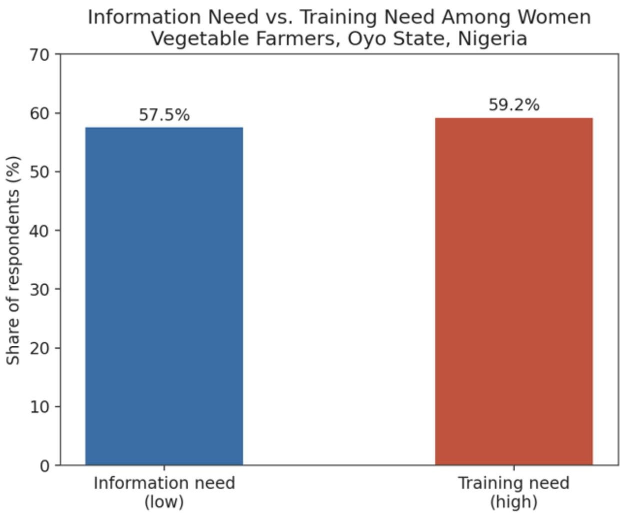

Figure 2: Information need versus training need among women vegetable farmers, Oyo State, Nigeria [11].

CONCLUSION

Vegetable growers' documented knowledge gaps in improved production technologies are not solely, or even primarily, an information problem. They occur within extension systems that are frequently understaffed relative to international benchmarks, and that inconsistently use the diagnostic tools — particularly Training Needs Assessment — available to target scarce training capacity where it is most needed. Distinguishing awareness gaps from knowledge gaps from adoption gaps, and matching each to a differentiated response, offers a more actionable path from knowledge-gap evidence to extension programme design than treating all three as a single undifferentiated "need for more training." Closing the vegetable knowledge gap durably will likely require parallel investment in extension workforce capacity, wider use of TNA-based curriculum design, gender-responsive delivery, and digital tools used to extend — rather than replace — hands-on, diagnostic training capacity.

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