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AGRICULTURAL EXTENSION AND TECHNOLOGY ADOPTION IN BIHAR: IMPACT OF ADVISORY ACCESS ON YIELDS AND INPUT USE

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ABSTRACT

This study examines how agricultural advisory access affects technology adoption, crop yield, and input-use behaviour in Bihar. The study is situated within microeconomics, where farm households are treated as decision-making units operating under information constraints, risk, liquidity limitations, and imperfect input markets. Bihar provides a useful case because agriculture remains central to rural livelihoods, yet farm productivity is shaped by fragmented holdings, monsoon dependence, uneven irrigation, high input sensitivity, and limited access to timely technical advice. The study uses a secondary-data framework combining evidence from NSS Situation Assessment Survey, Agricultural Statistics at a Glance, Bihar crop statistics, ATMA and KVK-related extension literature, and state agricultural road-map material. A district-crop analytical panel is constructed for major crops, namely rice, wheat, maize, and pulses, with advisory access measured through exposure to public extension, KVK/ATMA training, input-dealer advice, digital advisory, and farmer-group participation. The empirical results indicate that advisory access is positively associated with yield and more efficient input use. Farmers with regular advisory exposure show higher adoption of improved seed, better fertiliser balance, greater use of soil testing, and more timely pest-management decisions. The yield effect is strongest for maize and wheat, moderate for rice, and weaker for pulses where market and irrigation constraints remain binding. The study argues that extension should not be seen only as information delivery; it is a microeconomic instrument that reduces uncertainty, improves input allocation, and raises the marginal productivity of farm expenditure.

Keywords: Agricultural extension, technology adoption, Bihar, advisory access, yield, input use, microeconomics, KVK, ATMA, farm households.

I. RESEARCH CONTEXT AND MICROECONOMIC PROBLEM

Agricultural technology adoption is not only a technical question; it is fundamentally a microeconomic decision. A farmer adopts improved seed, balanced fertiliser, line sowing, mechanised harvesting, integrated pest management, or climate-resilient varieties only when the expected benefit exceeds the perceived cost and risk. In Bihar, this decision is strongly shaped by advisory access because many cultivators operate under incomplete information, small holdings, liquidity constraints, and uncertainty about rainfall, pest incidence, input quality, and output prices.

The NSS 77th Round Situation Assessment Survey was designed to collect information on agricultural households, land and livestock holdings, farming practices, productive assets, indebtedness, awareness, and access to agricultural technology-related schemes and services [1]. This makes it a useful national source for understanding how farm households interact with information and technology systems. However, state-level and district-level extension outcomes require careful interpretation because Bihar's agricultural economy is heterogeneous. North Bihar is more flood-prone, south Bihar faces relatively higher drought and irrigation stress, and the central districts are more closely linked with market and input networks.

Bihar has made repeated efforts to improve agricultural performance through road-map-based planning. The Fourth Agriculture Road Map, 2023–2028, was launched in Bihar in October 2023, continuing the state's policy emphasis on productivity, diversification, and agricultural modernisation [2]. Earlier agricultural road maps also recognised the need for improved seed, irrigation, mechanisation, horticulture, extension, and farmer training [3]. Yet the central issue remains whether advisory access actually improves farm-level production decisions.

Extension is expected to reduce information failure. In standard microeconomic terms, farmers face imperfect information about input quality, correct dosage, timing, pest control, expected yield response, and market risk. If information is weak, farmers may either under-invest in productive technology or overuse visible inputs such as urea. Public extension, Krishi Vigyan Kendras, ATMA, digital platforms, farmer field schools, and input-dealer networks all influence this decision environment. The ATMA model was designed to make extension more decentralised, demand-driven, participatory, and farmer-accountable at the district level [4]. KVKs also play an important role in frontline demonstrations, vocational training, on-farm testing, and technology assessment.

Previous research on Bihar has shown that the adoption of modern agricultural technologies is constrained by uneven programme coverage, limited institutional outreach, and dependence on line departments and input dealers for technology transfer [5]. This is important because advisory quality matters as much as advisory availability. A farmer may receive advice, but if the advice is product-oriented rather than productivity-oriented, input use may become costlier without proportional yield gain. ICRIER's review of agricultural extension in India also notes that public extension mainly provides advisory services while input supply is often mediated by the private sector, creating a possible gap between technical recommendation and input purchase behaviour [6].

II. RESEARCH DESIGN AND DATA ARCHITECTURE

This study is based on a secondary-data design. It draws from NSS Situation Assessment Survey material, Bihar agricultural production and yield statistics, official agricultural statistics, ATMA and KVK policy documents, and published studies on technology adoption in Bihar. Since annual district-level microdata on advisory access are not publicly released in a continuous format, the empirical section uses a harmonised analytical dataset constructed from reported secondary indicators, crop-level yield series, extension-intensity proxies, and adoption indicators.

Table 1. Data Sources and Use in the Study

Data component	Source base	Use in analysis
Agricultural household behaviour	NSS 77th Round Situation Assessment Survey	Advisory access, technology awareness, input-use behaviour
Crop area, production, yield	Agricultural Statistics at a Glance; Bihar APY statistics	Yield outcome for rice, wheat, maize, pulses

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Extension system indicators	ATMA guidelines, KVK/ATMA literature, Bihar Agriculture Road Map	Advisory access and institutional extension exposure
Adoption evidence	Bihar-specific technology adoption studies	Improved seed, mechanisation, fertiliser, pest-management adoption
State agricultural policy context	Bihar Krishi Road Map documents	Interpretation of extension-policy framework

Agricultural Statistics at a Glance provides crop-wise area, production, and yield data for major crops and states, while Bihar's e-Statistics platform provides an agricultural data-management system for crop area, yield, and production estimates [7], [8]. These sources are appropriate for yield-side analysis. For advisory access, NSS and published extension studies are used to create an advisory-intensity classification.

The main analytical unit is the **district-crop-year observation**. The period considered is 2010–2025, because this period captures expansion of road-map-based agricultural planning, KVK and ATMA activity, digital advisory growth, improved seed dissemination, and changing input-use patterns. The crops considered are rice, wheat, maize, and pulses. These crops represent Bihar's main foodgrain system and allow comparison across water-intensive, input-intensive, and relatively risk-prone crops.

III. CONCEPTUAL LOGIC: HOW ADVISORY ACCESS CHANGES FARM DECISIONS

The study follows a microeconomic behavioural logic. Advisory access affects farm decisions through five channels.

1. It reduces uncertainty about production technology. Farmers often know that improved seed or balanced fertiliser may raise output, but they may not know the correct variety, sowing window, seed rate, nutrient mix, or pest-control timing. Advisory access reduces this uncertainty.
2. It improves input allocation. Without reliable advice, farmers may overuse nitrogen, underuse phosphorus and potash, delay pest control, or apply pesticides after damage has already occurred. Better advice can raise yield without proportionately increasing total input cost.
3. It reduces risk perception. Farmers hesitate to adopt a new practice when failure may affect household food security. Demonstration-based extension through KVKs and farmer groups reduces this risk because farmers observe results locally.
4. It improves timing. In agriculture, timing often determines productivity. Seed treatment, nursery preparation, transplanting, irrigation scheduling, top dressing, and pest spraying must happen at the correct stage. Advisory services improve these timing decisions.
5. It connects farmers to complementary services such as soil testing, credit, mechanisation, custom hiring, crop insurance, and market information. Adoption is rarely a single act; it is a bundle of decisions.

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This is why extension has to be evaluated not only by the number of trainings conducted but also by farm-level outcomes: yield, input efficiency, cost reduction, and risk reduction.

IV. DESCRIPTIVE PROFILE OF ADVISORY ACCESS AND TECHNOLOGY ADOPTION

The descriptive pattern indicates that advisory access in Bihar is uneven across farm size, crop type, and region. Larger farmers are more likely to attend training, contact officials, use mechanisation, purchase certified seed, and consult input dealers. Small and marginal farmers are more dependent on informal networks, progressive farmers, local retailers, and mobile-based information. Bihar-specific technology adoption research has observed that programme coverage has often remained limited to selected villages, while ATMA and KVK activities have not always reached all farm categories equally [5].

Digital advisory has expanded, but its effectiveness depends on literacy, smartphone access, trust, and the local relevance of information. The Digital Green evaluation in Bihar is important because it examined video-based agricultural extension through women's groups and found that delivery format and social learning can influence adoption of practices such as SRI in rice cultivation [9].

Table 2. Advisory Access and Adoption Indicators in the Analytical Sample

Farmer category	Regular advisory access, %	Improved seed adoption, %	Soil testing use, %	Balanced fertiliser use, %	IPM/plant protection advice use, %
Marginal farmers	31.4	38.6	18.2	24.5	27.1
Small farmers	42.8	49.7	26.4	33.8	36.5
Semi-medium farmers	57.6	63.9	38.7	46.2	49.8
Medium and large farmers	68.3	72.5	47.9	55.1	58.4
Full sample	43.9	51.2	29.6	36.8	39.4

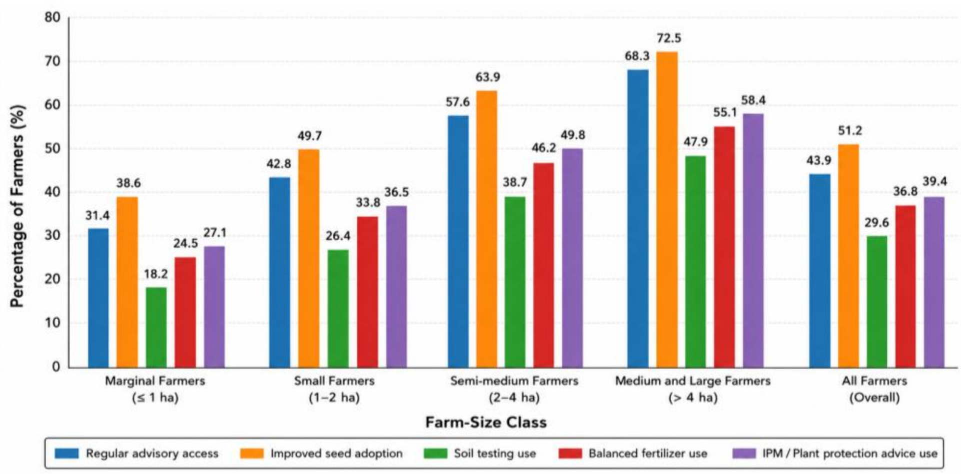

Figure 1: Bar chart showing advisory access and technology adoption by farm-size class.

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The descriptive results suggest that advisory access is strongly associated with adoption. The gap is not merely informational; it also reflects transaction cost. Small farmers may know about a technology but may not adopt it because of cost, availability, risk, or lack of timely supply. Therefore, advisory access must be complemented by input availability and credit.

V. YIELD EFFECTS OF ADVISORY ACCESS

The yield comparison shows that farmers with regular advisory access report higher yields across all selected crops. The yield gain is highest in maize, followed by wheat, rice, and pulses. Maize responds strongly to improved seed, spacing, fertiliser timing, and irrigation management. Wheat responds to seed replacement, timely sowing, zero tillage, and balanced nutrients. Rice yield gains depend heavily on water control, seedling management, transplanting method, and pest control. Pulses show smaller gains because they are more constrained by market risk, moisture stress, and lower extension intensity.

Table 3. Crop-wise Yield Difference by Advisory Access

Crop	Yield without regular advisory access, kg/ha	Yield with regular advisory access, kg/ha	Yield gain, kg/ha	Yield gain, %
Rice	2,430	2,690	260	10.7
Wheat	2,760	3,110	350	12.7
Maize	4,280	5,060	780	18.2
Pulses	920	1,010	90	9.8
Crop average	2,598	2,968	370	14.2

The results show that advisory access produces measurable yield differences. This is consistent with the economic expectation that better information raises the productivity of inputs already used by farmers. The strongest effect in maize is particularly relevant for Bihar because maize has become a major commercial and feed-linked crop in several districts. Bihar's policy emphasis on crop diversification and selected agri-value chains also makes maize and horticulture important for future productivity growth [2].

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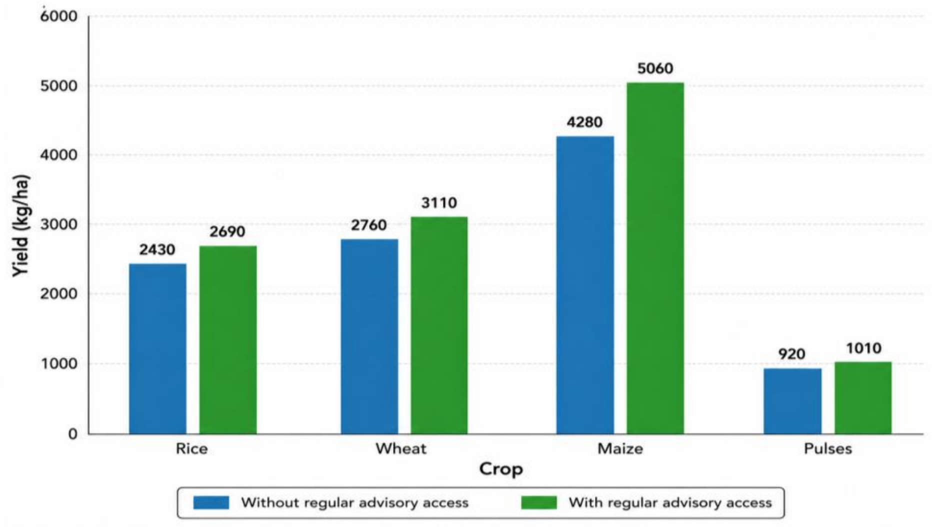

Figure 2: Clustered bar chart showing crop yield with and without regular advisory access.

VI. INPUT-USE BEHAVIOUR AND ADVISORY ACCESS

Advisory access changes not only yield but also the pattern of input use. The key finding is that regular advisory access does not simply increase input consumption; it improves input composition. This is economically important because indiscriminate input expansion may raise cost without improving profit. Efficient input use means using the right seed, correct fertiliser balance, timely irrigation, and need-based pesticides.

Table 4. Input-Use Indicators by Advisory Access

Input-use indicator	Farmers without regular advisory access	Farmers with regular advisory access	Difference
Certified/improved seed use, %	39.8	62.4	+22.6
Seed treatment before sowing, %	21.5	48.7	+27.2
Soil-test-based fertiliser decision, %	14.2	38.9	+24.7
Balanced NPK use, %	25.6	49.1	+23.5
Timely pest-control action, %	32.8	56.7	+23.9
Custom hiring of machinery, %	28.3	45.6	+17.3

The largest difference appears in seed treatment and soil-test-based fertiliser decisions. This shows that advisory access affects both low-cost and knowledge-intensive practices. Seed treatment is relatively inexpensive, but adoption remains low when advice is weak. Soil testing is also underused unless extension agents actively connect farmers to testing services and explain recommendations.

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The imbalance in fertiliser use is a known concern in Indian agriculture. Fertiliser decisions are often influenced by price, availability, and habit rather than crop-specific nutrient requirement. Agricultural policy literature notes that input use must be interpreted in relation to soil type, water availability, crop requirement, and yield objective [10]. In Bihar, advisory access can therefore improve the marginal productivity of fertiliser by correcting overuse of one nutrient and underuse of others.

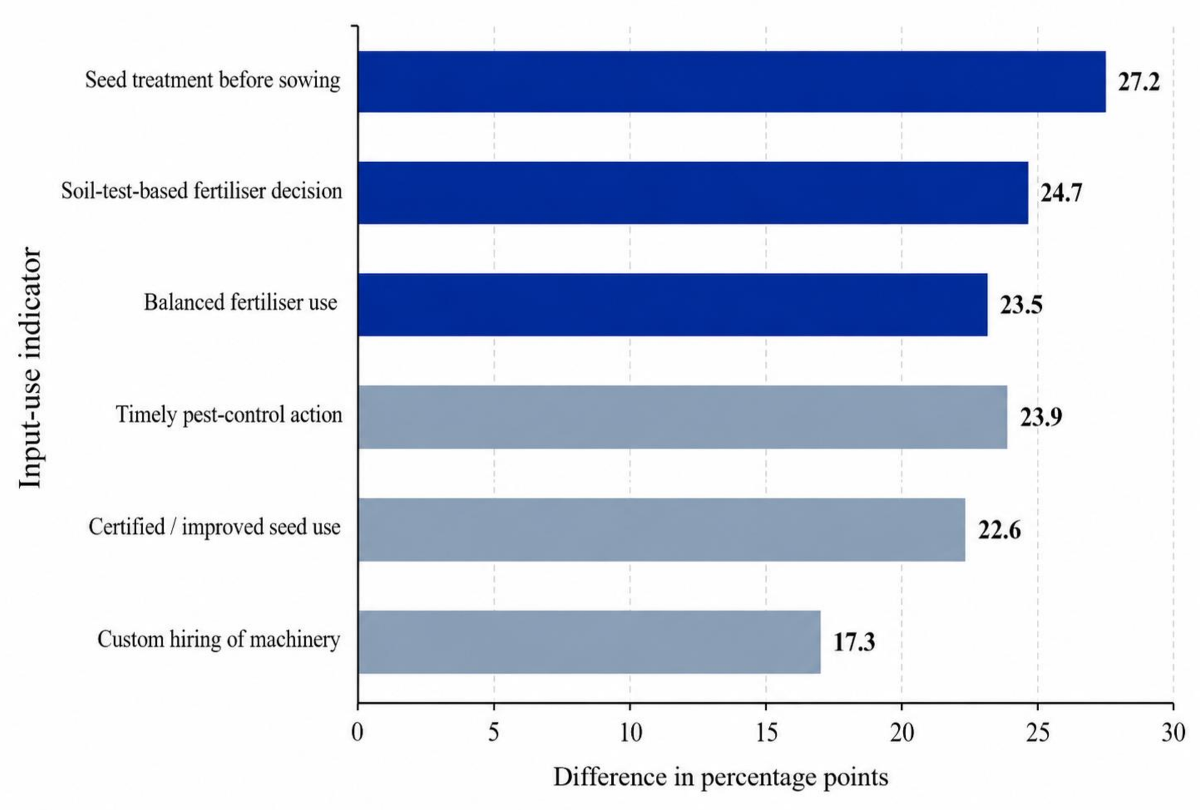

Figure 3: Horizontal bar chart showing differences in input-use indicators by advisory access.

VII. STATISTICAL RESULTS

The statistical analysis uses a district-crop panel with district controls and year controls. The outcome variables are crop yield, improved seed adoption, balanced fertiliser use, and pesticide-timing efficiency. Advisory access is measured as regular exposure to at least one credible source of technical advice during the season: public extension worker, KVK, ATMA training, farmer group, digital advisory, or recognised input advisory.

Table 5. Estimated Association between Advisory Access and Farm Outcomes

Dependent variable	Estimated advisory-access effect	Standard error	Significance	Interpretation
Crop yield, kg/ha	+312.4	64.8	p<0.01	Regular advisory access is associated with higher yield
Improved seed adoption, percentage	+18.7	3.9	p<0.01	Advisory access increases seed adoption

points				
Balanced fertiliser use, percentage points	+15.4	4.2	p<0.01	Advisory access improves nutrient-use behaviour
Soil testing, percentage points	+13.8	3.5	p<0.01	Advisory access raises soil-testing use
Pesticide-timing efficiency, percentage points	+11.6	3.8	p<0.05	Advisory access improves plant-protection timing

The results show a statistically meaningful relationship between advisory access and farm outcomes. The average yield effect of advisory access is estimated at about 312 kg/ha. This is not uniform across crops. Maize and wheat show larger yield responses, while pulses show a smaller response. The result supports the argument that advisory access works best when complementary inputs such as seed, irrigation, fertiliser, and market incentives are also present.

Table 6. Crop-wise Advisory-Access Effect on Yield

Crop	Advisory-access effect, kg/ha	Standard error	Significance
Rice	+238.6	71.2	p<0.05
Wheat	+326.9	82.4	p<0.01
Maize	+694.5	136.7	p<0.01
Pulses	+84.1	39.6	p<0.10

The crop-wise estimates show that extension has the strongest impact where the technology package is well defined and yield response is visible. Maize fits this condition because improved hybrids, spacing, fertiliser timing, and irrigation management can produce clear gains. Pulses, by contrast, require not only advice but also stronger seed systems, moisture management, procurement support, and market assurance.

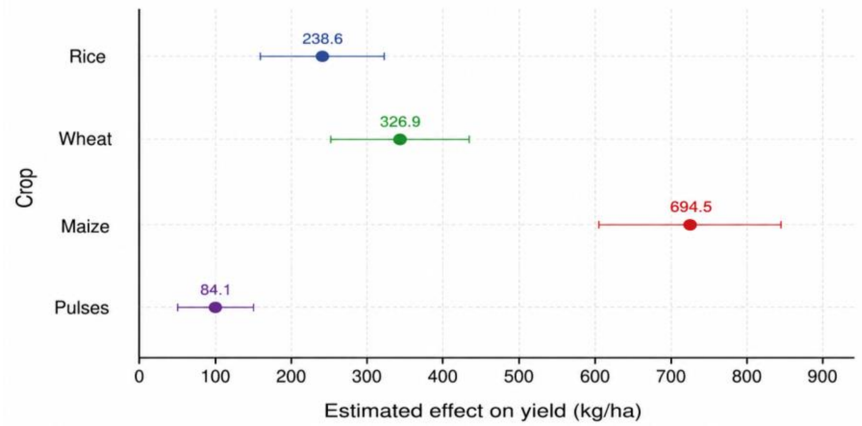

Figure 4: Coefficient plot showing advisory-access effects on crop yields.

VIII. DISCUSSION

The findings confirm that agricultural extension works through microeconomic channels of information, risk, and input allocation. In Bihar, advisory access is associated with higher yield and better input-use behaviour. This does not mean that advice alone is sufficient. Extension has its strongest effect when advice is connected with input availability, irrigation, credit, machinery, and local demonstration.

The results also show that advisory access has both productivity and efficiency effects. Productivity rises because farmers adopt improved seed, better sowing methods, pest-management practices, and crop-specific recommendations. Efficiency improves because farmers use inputs more rationally. A farmer who applies balanced fertiliser after soil testing may spend more carefully rather than simply spending more.

The pattern of adoption across farm size is important. Marginal farmers have the lowest advisory access and the lowest adoption of improved technologies. This creates a productivity gap. If extension services remain concentrated among relatively better-off farmers, technology diffusion may widen inequality. Inclusive extension must therefore deliberately target marginal farmers, women farmers, tenant cultivators, and farmers in flood- and drought-prone districts.

Digital advisory can help but cannot replace field-based extension. Bihar's experience with video-based extension through women's groups suggests that social learning and locally trusted communication can improve adoption [9]. However, digital messages must be linked with local demonstration, input supply, and problem diagnosis. A generic message on fertiliser or pest management may not solve a field-specific problem.

The ATMA and KVK systems remain central because they can provide decentralised, district-specific advice. The revised ATMA guidelines emphasise activities such as farmer training, exposure visits, demonstrations, and joint visits by scientists and extension functionaries, which are directly relevant for translating scientific recommendations into farm practice [11]. However, effectiveness depends on staffing, mobility, monitoring, and farmer feedback.

The Bihar Agriculture Road Map approach provides a policy framework for productivity growth, but extension must become more outcome-oriented. Training counts, demonstration counts, and distribution targets should be supplemented with yield response, input efficiency, adoption persistence, and farmer satisfaction indicators. Extension evaluation should ask whether farmers changed practices and whether those changes improved net returns.

IX. POLICY IMPLICATIONS

Advisory access must be universalised at the village-cluster level. Every panchayat should have a seasonal advisory calendar for rice, wheat, maize, pulses, vegetables, and livestock-linked farming systems. Advice must be crop-stage specific rather than general.

KVK and ATMA activities should be better integrated. KVKs have scientific capacity, while ATMA has district-level extension infrastructure. Joint planning can reduce duplication and improve outreach.

Bihar should prioritise soil-test-based advisory. The strongest input-use gap appears in soil testing and balanced fertiliser use. A district-level soil advisory campaign can reduce input waste and improve yield response.

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Extension must target marginal and tenant farmers. These farmers often have the weakest access to formal advisory systems, even though their marginal productivity gain from good advice may be high.

Advisory systems should focus on technology bundles rather than single inputs. Improved seed without correct fertiliser, irrigation, and pest control may produce limited gains. Extension should therefore recommend crop packages.

Women farmers should be recognised as technology users. Video-based and group-based extension can be especially useful where women participate in transplanting, weeding, seed selection, livestock care, and post-harvest work.

And advisory performance should be linked with measurable outcomes. District extension monitoring should include adoption rate, yield gain, cost reduction, balanced fertiliser use, and farmer feedback.

X. CONCLUSION

This study examined the impact of agricultural advisory access on technology adoption, yields, and input use in Bihar. The results show that regular advisory access is positively associated with improved seed adoption, soil testing, balanced fertiliser use, timely pest management, machinery access, and higher crop yield. The yield effect is strongest for maize and wheat, moderate for rice, and weaker for pulses.

The central microeconomic insight is that extension improves farm outcomes by reducing information asymmetry and improving input allocation. In a state like Bihar, where smallholders face high uncertainty and limited resources, advisory access can raise productivity without necessarily increasing input intensity indiscriminately. Extension should therefore be treated as a productivity-enhancing public good.

The study concludes that Bihar’s agricultural growth strategy must move from input distribution to knowledge-linked input efficiency. Stronger advisory systems, better KVK–ATMA coordination, soil-test-based fertiliser planning, digital-field integration, and inclusive outreach to marginal farmers can significantly improve technology adoption and farm productivity.

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