

A study on private sector contributions to enhancing nutritious, diverse food production and consumption in southern Bangladesh

Abstract

Background and study areas: Southern Bangladesh faces challenges related to nutritious food production, quality inputs, and technological solutions. Agro-input companies are key players in providing seeds, fertilizers, and services to promote agricultural farming and diverse, nutritious food production. The study examined the role of agro-input companies in enhancing nutritious, diverse food production and consumption for Khulna and Faridpur districts.

Methods: This study employed a mixed-methods approach, combining qualitative and quantitative surveys, and triangulated the findings with secondary data to strengthen the results.

Results: This study examines the role of agro-input companies in promoting nutritious and diverse food production and consumption in southern Bangladesh, focusing on Faridpur and Khulna districts. A mixed-method approach was applied, combining quantitative household surveys and qualitative assessments. The study revealed that 89.00% of farmers significant learning from agro-input companies in homestead gardening, 80.71% nutritious food production and consumption, and 74.50% improved vegetable varieties, whereas 52.49% of farmers increased their knowledge of diversified production techniques. Support from agro-input companies enabled the adoption of improved practices, with homestead gardening 68.45%, new technologies 64.00%, and diverse vegetable varieties 52.00% being the most extensively adopted. 69.31% of farmers also adopted high-yielding seeds, 74.56% of raised-bed planting, and 13.21% of stress-tolerant varieties remained limited. At the household level, across both districts, 43.85% consumed all produce, 26.08% sold surplus, and 29.35% shared excess. Consumption of nutritious foods improved significantly, with 44.78% of households reporting increases of more than 70% in vegetable consumption. Access to agricultural inputs was generally high, with 83.98% of households confirming the availability of quality inputs in both districts. Overall, the findings highlight that agro-input companies play a critical role in promoting nutrition, diverse food production by facilitating the adoption of new technologies, improving household dietary diversity, and strengthening the agricultural inputs supply chain, thereby contributing to sustainable and diverse food production in southern Bangladesh.

Conclusion: Agro-input companies significantly promote quality seeds, fertilizer, new technologies, farming education, and market linkages to enhance nutritious and diverse food production in southern Bangladesh. The training and embedded services boost farmer adoption, contributing to increased production and dietary diversity, surplus sales, and sustainable agricultural practices.

Keywords: Private sector, agro-input company, nutritious, diverse food production, consumption,

1. INTRODUCTION

Agro-input companies in southern Bangladesh improve the production of nutritious, diverse food and diversity by promoting high-yielding seed varieties, improved technologies, fertilizers, and pesticides, hopeful farmers to diversify nutritious food production. The studies examine the agro-inputs companies' role in promoting access to quality inputs, education, technological solutions, and digital services (Barua et al., M., 2021). Farmers' access to nutritious and diverse food remains a significant challenge in southern Bangladesh, where agricultural practices are mostly cereal crop-based. This situation contributes to nutritional insufficiencies and inadequate dietary diversity among rural households. To ensure improved seeds, fertilizers, pesticides, and advisory services, agro-input companies play an important role in influencing agricultural farming to produce diverse crops.

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Households' nutritious food production and consumption of more diverse diets in Bangladesh (Shankar, 2019).

The private sector contribution to nutritious, diverse food production by promoting quality inputs and modern technology is crucial for agricultural farming. Agro-input firms not only supply essential inputs but also influence farmers' decisions on crop variety selection, production techniques, and market engagement (Mbutia, 2016). In the Faridpur and Khulna districts, companies have promoted demonstrations, strengthened input supply chain networks through last-mile sales agents, retailers, distributors, and organized farmer meetings, including advisory services. Since nutritious food production depends on inputs such as land, water, seeds, and fertilizers, challenges such as declining soil fertility, water scarcity, limited access to quality seeds and fertilizers, and land conversion threaten agricultural sustainability in Bangladesh (Khan, 2023). Evidence from southern Bangladesh suggests that agricultural training modestly increases vegetable varieties in homestead gardens. Remarkably, improved agricultural practices and nutrition training highly contributed to both food consumption and dietary diversity, whereas adding training significantly enhanced outcomes beyond these integrated approaches (Ahmed et al., 2024).

Agro-input companies have emerged as important actors in the agriculture sector, particularly in areas with limited access to public extension services, improved seed varieties, and technologies. Bangladesh's agrifood sector must overcome constraints such as environmental degradation, poor infrastructure, and weak market integration (Ahmed et al., 2021). The private sector provides essential inputs, including seeds, fertilizers, pesticides, and modern equipment, along with advisory services that guide farmers on variety selection, production methods, and post-harvest management (Mbutia, 2016). By introducing high-yielding and nutrient-dense crop varieties, the companies directly enhance the availability of diverse and nutritious foods at both household and community levels. Furthermore, their guidance on fertilizer use, pest control, and irrigation contributes to improved crop productivity and quality, thereby supporting both food production and consumption.

The potential of the private sector to contribute to nutrition-sensitive agriculture has gained increasing attention in global development. Nutrition-sensitive agriculture emphasizes the production of nutrient-rich crops and the promotion of dietary diversity (Ruel et al., 2013). Agro-inputs play dual roles as suppliers of inputs and service providers, which influence both the supply and demand sides of the food system. Encouraging the cultivation of vegetables can help households gain access to essential nutrients and income. The private sector companies, by leveraging their expertise and local networks, are well-positioned to facilitate these changes. The supply chains often extend into remote rural areas, which can ensure the timely availability of high-quality seeds and other inputs to overcome barriers to crop diversification. Furthermore, the advisory services provided by these companies can empower farmers to adopt improved cultivation techniques, optimize input use, and enhance post-harvest handling, thereby reducing losses and improving household food availability. By promoting the cultivation of diverse crops and supporting market linkages, agro-input companies can also contribute to income generation, enabling households to purchase additional nutritious foods and further improve their dietary patterns.

Despite the increasing involvement of agro-input companies in promoting diverse food production, their role in enhancing food consumption patterns has received limited academic attention, particularly in the context of Bangladesh's southern region (Feed the Future Bangladesh Rice and Diversified Crops Activity, 2021). In southern Bangladesh, particularly in the Faridpur and Khulna districts, agro-input companies have strengthened supply chain networks by incorporating sales agents, local retailers, and extension service providers, ensuring that farmers have reliable access to seeds, fertilizers, and other inputs. Farmer meetings, advisory sessions, and household visits further complement these efforts by providing tailored guidance on crop management and nutrition-sensitive

farming practices. Such interventions reflect a growing recognition within the private sector that commercial success is intertwined with improved farmer livelihoods, household nutrition, and sustainable agricultural production.

Most studies have focused on government-led programs, non-governmental organization (NGO) initiatives, or large-scale development projects, with less attention given to the private sector's contribution. This gap is especially notable in southern Bangladesh, a region highly vulnerable to climate change, soil salinity, waterlogging, and other environmental stresses that threaten agricultural productivity and household food security. Saltwater intrusion and rising sea levels, combined with erratic rainfall patterns, reduce the availability of arable land and freshwater for irrigation, posing significant challenges for crop diversification. In such contexts, the involvement of agro-input companies in providing resilient, nutrient-rich crop varieties and appropriate cultivation techniques can be crucial in sustaining production and supporting dietary improvements.

Several studies have highlighted the importance of combining agricultural interventions with nutrition-focused approaches to achieve meaningful improvements in household diets. For instance, integrated programs that provide seeds for vegetables, alongside training on nutritious food production, have been shown to increase both the diversity of crops grown and the frequency of consumption of nutrient-rich foods. This study aims to fill the existing knowledge gap by investigating how agro-input companies contribute to enhancing nutritious and diverse food production and consumption in southern Bangladesh. Specifically, the study focuses on the products, services, and advisory interventions provided by these companies, and their interactions with farming communities. By examining the pathways through which private sector actors influence variety choices, cultivation practices, and household dietary behaviors, the study seeks to provide evidence-based insights for promoting nutrition-sensitive agriculture. The analysis also considers the broader socioeconomic and environmental context of southern Bangladesh.

To address this gap, the study employs a mixed-method approach to assess the role of private sector agro-input companies in promoting nutritious and diverse food production and consumption in southern Bangladesh. It provides a comprehensive analysis of the interactions between nutritious food production, technology adoption, and household dietary patterns. By examining how improved seeds, fertilizers, and advisory services influence farming practices, the study highlights critical pathways that shape nutritional outcomes. The findings offer new insights into the connections between agricultural input markets, farming households, and consumer choices within the broader context of food security and nutrition in Bangladesh.

2. MATERIALS AND METHODS

2.1 Methodologies:

This study employed a mixed-methods approach, combining household surveys and key informant interviews (KIIs) to assess the role of private sector agro-input companies in enhancing nutritious and diverse food production and consumption in southern Bangladesh. A simple random sampling technique was used to select respondents, and the sample was proportionately distributed across the study districts to ensure representativeness. KIIs captured in-depth perspectives on agro-input company activities, farmer engagement, and supply chain dynamics. Additionally, secondary data from previous research publications were analyzed to measure private sector contributions and complement the results of both quantitative and qualitative surveys. Study findings were presented using statistical generalization methods, including percentages, graphs, and tables. Primary quantitative data were collected from two sub-districts in each district, while qualitative data were collected by the local enumerators, and secondary data were sourced from research articles and government reports.

2.2 Sampling

The study employed a proportional stratified random sampling technique to select households from Khulna and Faridpur districts. The sample size was determined at a 95% confidence level with a 5% margin of error to ensure representativeness. A total of 385 households were surveyed. A total of 15 Key informant interviews (KIIs) were conducted, including 5 retailers, 5 sales agents, 5 company representatives, and other relevant stakeholders, selected purposively based on their role in the agro-input supply chain.

2.3 Survey tools development

This study employed a participatory approach to develop and finalize tools for both quantitative and qualitative data collection. Initially, existing reports, literature, and journal articles were reviewed to identify key problem areas and generate preliminary ideas for the tools. Draft versions of the household survey questionnaire and key informant interview (KII) guide were then prepared and shared with local experts through virtual meetings to obtain feedback. Incorporating the expert feedback, the tools were revised and shared again for final validation. Data enumerators were oriented through virtual training sessions to ensure accurate and consistent management. The finalized tools were meticulously designed to capture relevant information on agro-input usage, production practices, dietary diversity, and market engagement. For efficient field data collection, the tools were digitized using the KoboToolbox platform, enabling systematic recording, storage, and management of survey responses.

2.4 Data collection and analysis

Data were collected from Khulna and Faridpur districts, ensuring consistency, accuracy, and adherence to ethical standards. Key informant interviews (KIIs) were conducted based on respondent availability and willingness. Collected data were cleaned and analyzed using SPSS, with primarily descriptive statistics employed to summarize household practices, adoption of technologies, dietary diversity, and the role of agro-input companies in promoting nutritious and diverse food production.

2.5 Limitations of the Study

This study has several limitations. First, the findings are based on selected districts and may not fully represent the situation in all of southern Bangladesh. Second, the household survey relied on self-reported data, which may be subject to recall bias. Third, the study focused on the role of agro-input companies and did not extensively assess other factors influencing dietary diversity. Finally, the sample size for KIIs was limited, which may restrict the generalizability of qualitative insights. Despite these limitations, the study provides valuable insights into how private-sector agro-input companies contribute to nutritious and diverse food production and consumption in the region.

3. RESULTS AND DISCUSSION

3.1 Farmers report to learn from agro-inputs companies

The study assessed the farmers' reported learning different agricultural and nutrition-related practices from agro-input companies in Faridpur and Khulna districts (Table 1). Overall, the findings revealed that agro-input companies significantly contributed to farmers' awareness of nutritious, diverse food production practices. Specifically, 89.00% of farmers reported gaining knowledge on homestead gardening, 80.71% nutritious food production and consumption, and 74.50% on using improved vegetable varieties. Similarly, 75.70% of farmers learned about new technologies, 67.00% reported exposure to safe food production and consumption, 65.75% learned production techniques, and 52.49% learned diversified food production techniques. Farmers in Khulna reported higher levels of learning compared to those in Faridpur, particularly for safe food production and consumption (80.34% vs. 53.68%) and nutritious food production and consumption (86.32% vs. 75.09%), indicating effective engagement of agro-input companies in Khulna.

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Table 1: Farmers reported learning from agro-inputs companies

Farmers reported learning from agro-inputs companies	Faridpur (%)	Khulna (%)	Total (%)
Diversified food production techniques	47.72	57.26	52.49
Nutritious food production and consumption	75.09	86.32	80.71
Safe food production and consumption	53.68	80.34	67.00
Homestead gardening	87.37	90.60	89.00
New technology	77.89	73.50	75.70
Vegetable varieties	72.00	77.00	74.50
Production techniques	68.00	63.50	65.75

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These findings highlight that agro-input companies serve not only as suppliers of agricultural inputs but also as crucial knowledge providers, particularly in promoting homestead gardening and nutrition-sensitive practices. A study found that the majority lacked training from agro-input companies. Specifically, about 86% and 90% of respondents reported no formal training on fertilizer and pesticide usage, respectively, highlighting a gap in industry-led education (Titumir, R.A.M., 2021). Overall, engagement with agro-input companies effectively enhances farmers' knowledge and technology adoption, supporting the production of nutritious and diverse foods.

3.2 Agro-input companies support farmers to produce nutritious and diverse food.

The study found that support from agro-input companies played a significant role in enabling farmers in Faridpur and Khulna to produce nutritious and diverse food. In Khulna, 68.45% of farmers reported receiving substantial support for homestead gardening, compared to 66.00% in Faridpur. Support for the adoption of new technologies was reported by 64.00% of farmers in Khulna and 58.80% in Faridpur. Similarly, 49.00% of farmers in Khulna indicated receiving assistance for nutritious food production, while 45.00% of farmers in Faridpur reported the same. Additionally, 52.00%, 43.00%, and 41.50% of farmers in Khulna reported receiving support for safe food production, including improved vegetable varieties and diversified food production techniques, compared to 47.30%, 38.00%, and 37.25% in Faridpur, respectively. Among the different types of support, homestead gardening emerged as the most widely adopted practice, with 67.23% of farmers reporting support for homestead gardening, 61.40% adoption of new technologies, and 49.65% access to diverse vegetable varieties. Support for nutritious food production and consumption was reported by 47.00% of respondents, while 42.50% farmers reported that safe food production and consumption.

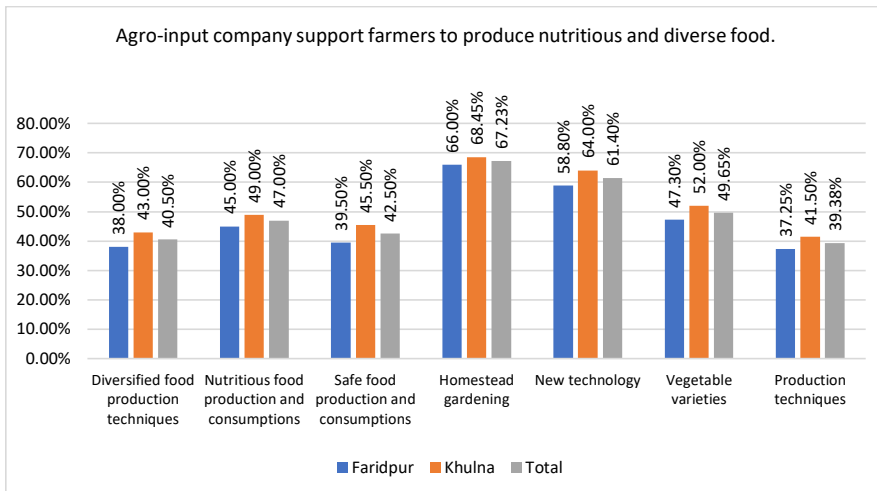


Figure 1: Agro-input company supports farmers to produce nutritious and diverse food.

A study highlights the significance of homestead gardening in enhancing food security and dietary diversity, particularly in coastal regions of Bangladesh **Alam et al., 2024**). The study emphasizes the importance of integrating crop diversification and climate-resilient practices to improve household nutrition. **Schreinemachers et al. (2025)** provide evidence of the positive impact of home gardens on food and nutrition in rural Bangladesh, noting that such interventions can simultaneously raise household vegetable demand and supply. **Mohammad, I., and Dey, N.C. (2025)** discuss how the high cost of agricultural inputs, in the absence of subsidies, can be a barrier to technology adoption among farmers in Bangladesh. Overall, these findings suggest that agro-input companies are effectively promoting household-level nutrition and crop diversity, particularly through gardening, technology adoption, and the provision of improved seeds. Strengthening broader production practices and food safety initiatives could further enhance farmers' capacity for sustainable and diverse food production.

3.3 Farmers' adoption of new technologies for nutritious and diverse food production

A study was conducted in Faridpur and Khulna districts to assess farmers' adoption of new agricultural technologies. The findings revealed that 69.31% of farmers adopted high-yielding seed varieties, while 40.50% used nutrient-rich and 13.21% stress-tolerant varieties. Climate-smart techniques were increasingly practiced, with 74.56% using raised-bed planting, 36.38% applying mulching, and 52.67% using drip irrigation. In soil fertility management, 61.08% used organic inputs, 39.20% balanced fertilizers, and 54.50% reduced chemical use. For safe food production, 62.65% practiced safe pesticide use, and 32.70% adopted biological pest control. Post-harvest management practices showed 90.81% ensured safe transportation, while 22.08% used low-cost storage and 17.45% applied local preservation methods. Overall, adoption levels were higher in Khulna for sustainable and organic practices, while Faridpur farmers showed stronger engagement in improved seed use and raised-bed cultivation. These trends indicate growing awareness of sustainable, climate-resilient, and safe food production practices among farmers.

Table 2: Farmers' adoption of new technologies for nutritious and diverse food production

Farmers adopted new technologies.	Faridpur (%)	Khulna (%)	Total (%)
Improved and hybrid seed varieties			
High-yielding varieties	69.32	69.30	69.31

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Nutrient-rich varieties	43.00	38.00	40.50
Stress-tolerant varieties	13.26	13.16	13.21
Climate-smart cultivation techniques			
Raised-bed for planting	83.33	65.79	74.56
Mulching to retain soil moisture	28.03	44.74	36.38
Drip irrigation kits for water efficiency	43.94	61.40	52.67
Soil fertility and input management			
Soil treatment	31.82	44.74	38.28
Use of organic	48.48	73.68	61.08
Balanced fertilizer	45.08	33.33	39.20
Reduced chemical	52.00	57.00	54.50
Safe food production technologies			
Safe pesticide use	65.50	59.80	62.65
Biological pest control	28.65	36.75	32.70
Post-harvest handling and storage			
Safe transportation of vegetables	89.40	92.20	90.81
Low-cost improved storage	17.65	26.50	22.08
Local preservation methods to reduce nutrient losses	13.30	21.60	17.45

A comparative analysis of farmers in Faridpur and Khulna shows varying levels of adoption of modern agricultural technologies. In seed improvement, about 69.32% of farmers in both districts used high-yielding varieties, while 43.00% in Faridpur and 38.00% in Khulna adopted nutrient-rich seeds. Climate-smart practices were more common in Faridpur, with raised-bed planting at 83.33%, whereas Khulna led in mulching at 44.74% and drip irrigation at 61.40%. Khulna also showed higher use of organic inputs at 73.68% and soil treatment at 44.74%. Safe food and post-harvest practices were widely applied, especially the safe transportation of vegetables, over 89% in both regions, indicating growing awareness of sustainable farming.

A study by **Islam, M.K., and Farjana, F. (2024)** highlighted the adoption rates of various practices, including raised-bed planting and mulching, which align with your findings. This study underscores the importance of such practices in enhancing agricultural resilience in the region. Research by **Babu et al. (2025)** identified key determinants such as education level, farm size, and access to training, which are crucial for understanding the adoption of safe food production technologies like biological pest control methods. **Billah et al. (2025)** study highlights challenges such as high input costs and limited access to resources, which may affect the adoption of technologies like drip irrigation and organic fertilizers. Key insights from key informant interviews, the adoption of productivity-enhancing technologies (e.g., high-yielding seeds, raised-bed planting, safe transportation) was consistently high. While the agro-inputs companies have successfully promoted the adoption of several technologies to produce nutritious and diverse food for consumption. A study in Chapainawabganj reported that 90.5% of vegetable farmers occasionally adopted farming technologies, including inorganic fertilizers, tractors, and smartphones (**Khan et al., 2022**). Similarly, participation in Farmer Field School (FFS) programs revealed that 59.3% of farmers adopted technologies such as farm yard manure (**Islam et al., 2023**).

3.4 Households utilized the harvested vegetables

The utilization of harvested vegetables by households in Faridpur and Khulna districts shows distinct patterns, reflecting both consumption habits and local market engagement. In Faridpur, 42.40% of households consumed all their harvested vegetables, while 22.81% sold the surplus produce, and 11.00% shared excess with neighbors. In Khulna, a higher proportion of households, 45.30%, consumed all harvested vegetables, while 29.35% sold surplus and 14.50% shared with neighbors. Overall, across both districts, 43.85% of households consumed all harvested vegetables, 26.08% sold

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surplus produce, and 29.35% shared excess with neighbors. These results indicate that while the majority of households prioritize household consumption, there is also a significant portion engaging in market sales or community sharing. The higher percentage of vegetable sales and sharing in Khulna suggests a stronger link to local markets and community networks compared to Faridpur. Such utilization patterns are important for understanding household food security, income generation, and social cohesion. The findings highlight the need for targeted interventions to support post-harvest management, market access, and community-based sharing mechanisms, which can enhance both nutritional outcomes and economic benefits for smallholder vegetable farmers.

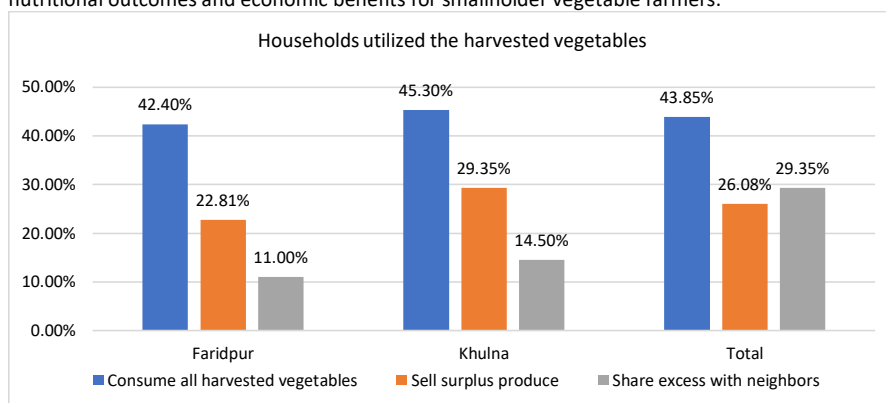


Figure 2: Households utilized the harvested vegetables

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These findings align with prior studies in Bangladesh, which show that home gardeners often retain the majority of their produce for household use (Khan et al., 2022). Sharing behavior reflects social capital practices documented in food security literature, where surplus food exchanged within social networks serves as a safety net for those facing food shortages (Nosratabadi et al., 2020). Similarly, Baliki et al. (2022) report that home garden interventions can improve both production and consumption of vegetables among households. Akter (2019) also found that rural women showed high acceptance of home gardening, with households primarily viewing their gardens as a source of nutrition rather than income generation. This supports the idea that subsistence consumption dominates over sales or sharing. Overall, the results indicate that vegetable production serves multiple purposes, providing not only nutritional benefits for households but also opportunities for economic gain and community strengthening. The majority of households prioritized self-consumption, highlighting the importance of subsistence farming in addressing dietary needs and reducing household dependence on external food sources.

3.5 Households increased sales of nutritious foods

The study found that households in both Faridpur and Khulna reported an increase in the sale of nutritious foods compared to the previous year, though the scale of growth varied across regions. In both districts, the largest proportion of households reported sales increases of less than 30%, with 14.00% in Faridpur and 15.00% in Khulna. Moderate increases between 30–39% were observed in only 3.00% of households in Faridpur, but 15.00% in Khulna. Similarly, 2.00% of households in Faridpur and 9.00% in Khulna reported increases between 40–49%, with a total of 6.97%. Higher increments in sales were less common. For increases of 50–59%, 4.91% of households in Faridpur and 6.84% in Khulna (5.47% overall) reported such changes. Increases between 60–69% were observed among 4.56% of households in Faridpur and 8.00% in Khulna, averaging 6.00%. The proportion of households reporting more than 70% sales growth was minimal, with only 2.00% in Faridpur and 3.42% in Khulna, amounting to 3.00% overall.

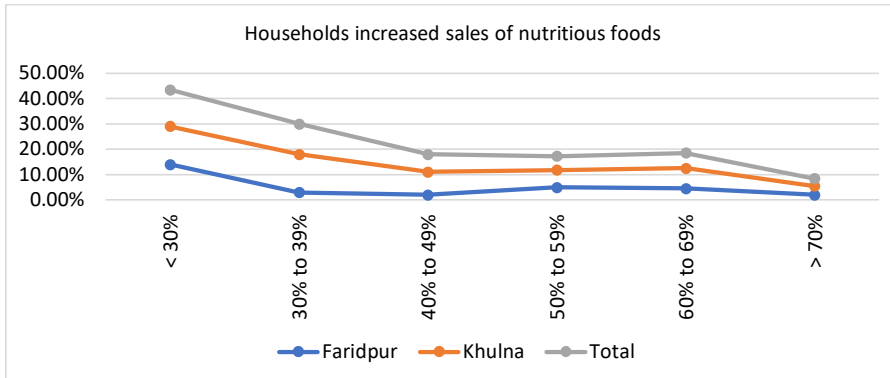


Figure 3: Households increased sales of nutritious foods

Previous studies in Bangladesh have similarly noted that while homestead and smallholder production improves household food availability, the transition from subsistence to commercial sales is often constrained by structural and institutional factors (Baliki et al., 2022; Akter, 2019). Overall, the results indicate that nutritious food production primarily serves household consumption needs, but with growing potential for income generation. Regional differences underscore the importance of context-specific strategies that address local barriers while leveraging opportunities for commercialization.

3.6 Increase in household nutritious food consumption compared to the previous year.

The study examined changes in household vegetable consumption in Faridpur and Khulna, comparing this year's consumption to the previous year. The findings indicate a clear upward trend in household vegetable consumption in both Faridpur and Khulna, with nearly half of households (44.78%) reporting increases exceeding 70% compared to the previous year. Faridpur showed notable improvements, but Khulna outperformed with over 60% of households reporting very high increases, likely reflecting better access to extension services, markets, and nutrition-awareness initiatives. Moderate increases (30–59%) were less common, suggesting that once households adopt improved practices or expand production, consumption gains tend to be substantial.

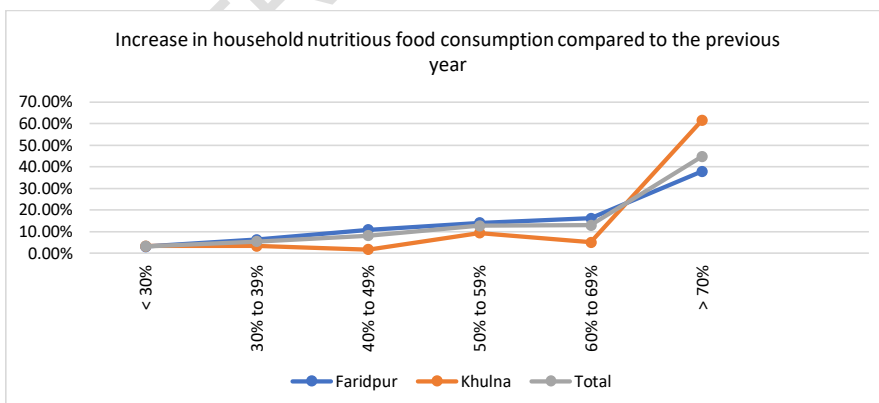


Figure 4: Increase in household nutritious food consumption compared to the previous year

These results align with previous studies in Bangladesh. Homestead gardening and smallholder vegetable cultivation have been shown to enhance dietary diversity and micronutrient intake (Khan

et al., 2022; Baliki et al., 2022). The concentration of high consumption of effective nutrition-sensitive agriculture interventions, which improve household diets and reduce dependence on purchased foods (Baliki et al., 2022). Community-level knowledge sharing and social capital further support these gains (Nosratabadi et al., 2020). Overall, households are moving toward greater self-sufficiency in vegetable consumption, with important implications for nutrition security. To sustain and scale these gains, policies should strengthen home garden programs, improve access to agricultural inputs, and expand nutrition-awareness campaigns. Regional differences, such as Khulna’s stronger performance, indicate the need for localized approaches that address specific production constraints while leveraging community practices.

3.7 Households reported on the availability of agricultural inputs

Households in Faridpur and Khulna reported high levels of access to agricultural inputs (Table 1). In Faridpur, 82.45% of households confirmed availability of inputs, slightly lower than 85.50% in Khulna, with an overall rate of 83.98% across both districts. Only 15.09% of households in Faridpur and 8.55% in Khulna reported lacking access, while a small proportion indicated “don’t know” (1.32% in Faridpur and 3.75% in Khulna) or “other” responses (1.14% in Faridpur and 2.21% in Khulna), representing 2.54% and 1.67% overall, respectively.

Table 3: Households reported on the availability of agricultural inputs

Households reported on the availability of agricultural inputs	Faridpur (%)	Khulna (%)	Total (%)
Yes	82.45	85.50	83.98
No	15.09	8.55	11.82
Don’t know	1.32	3.75	2.54
Other	1.14	2.21	1.67

These findings highlight disparities in access to agricultural inputs, which are critical for improving productivity, supporting diversified cropping systems, and enhancing household nutrition (FAO, 2019; Ahmed et al., 2021). The higher reported availability in Khulna may reflect better market connectivity, local extension services, or targeted agricultural programs, while the substantial “don’t know” responses suggest limited awareness or insufficient outreach in both districts. Such gaps can constrain the adoption of improved seeds, fertilizers, and other inputs, ultimately affecting smallholder productivity and food security (World Bank, 2020). Addressing these disparities requires strengthening local input supply chains, enhancing farmer awareness through extension services, and promoting equitable access to quality agricultural inputs, enabling households to effectively utilize them to improve yields, diversify production, and support nutritional outcomes (FAO, 2019; Ahmed et al., 2021). While some households, particularly in Khulna, reported better access to agricultural inputs, a significant proportion either lacked access or were unaware of their availability. These findings underline the need for improved information dissemination, more efficient supply chains, and targeted support to ensure equitable input access across regions.

3.8 Households reported access to agricultural inputs

Households in Faridpur and Khulna reported high levels of access to agricultural inputs, although some regional differences were evident (Table 3). In Faridpur, 76.25% of households indicated access to inputs, compared to 81.55% in Khulna, with an overall rate of 78.90% across both districts. Households without access comprised 13.09% in Faridpur and 8.55% in Khulna, totaling 10.82%. A small proportion reported being unaware of availability (3.32% in Faridpur and 3.70% in Khulna, 3.51% overall), while “other” responses, possibly reflecting alternative access arrangements or informal sources, accounted for 7.34% in Faridpur and 6.21% in Khulna.

Table 4: Households reported access to agricultural inputs.

Households reported access to agricultural inputs.	Faridpur (%)	Khulna (%)	Total (%)
Yes	76.25	81.55	78.90
No	13.09	8.55	10.82
Don't know	3.32	3.70	3.51
Other	7.34	6.21	6.77

These findings highlight that the majority of smallholder households have access to key agricultural inputs, which are essential for enhancing productivity, supporting crop diversification, and improving household nutrition (FAO, 2019; Ahmed et al., 2021). The slightly higher access reported in Khulna may be attributed to better extension services, more efficient supply chains, or regional development initiatives. Nevertheless, the existence of households without access or uncertain about input availability underscores the need for targeted outreach, improved information dissemination, and strengthened input supply systems to ensure equitable access across regions (World Bank, 2020). Enhancing availability and awareness of quality inputs, including improved seeds, fertilizers, and pest management tools, can support smallholders in improving yields, diversifying production, and ultimately contributing to better food security and nutritional outcomes (FAO, 2019; Ahmed et al., 2021). This may represent regular access and availability of agricultural inputs, with agro-input companies playing a crucial role in promoting quality inputs within the community. Overall, these companies' initiatives can empower households to adopt sustainable agricultural practices, increase yields, diversify production, and improve food security and nutrition outcomes.

4. CONCLUSION

This study provides clear evidence that agro-input companies play a vital role in strengthening nutrition-sensitive agriculture and enhancing farmers' capacity to produce and consume diverse and nutritious food in Faridpur and Khulna districts. The findings demonstrate that farmers have benefited from knowledge dissemination, technical support, and improved access to agricultural inputs facilitated by these companies. A high proportion of farmers reported learning about homestead gardening, nutritious food production, safe food practices, and new technologies, with Khulna showing relatively stronger outcomes than Faridpur. The findings of this study confirm that agro-input companies are making an important contribution to nutrition-sensitive agriculture in Faridpur and Khulna districts by promoting improved practices, enhancing access to inputs, and encouraging the adoption of new technologies. Evidence shows that 89.00% of farmers reported learning about homestead gardening, 80.71% about nutritious food production and consumption, and 74.50% about improved vegetable varieties through company engagement. Knowledge transfer was more effective in Khulna, where 86.32% of farmers learned about nutritious food production compared to 75.09% in Faridpur, and 80.34% learned about safe food production compared to 53.68% in Faridpur. This demonstrates both the scale and geographic variation in the effectiveness of private sector engagement. Support from agro-input companies enabled farmers to enhance food diversity and nutrition, with homestead gardening benefiting 67.23%, new technologies 61.40%, and improved vegetable varieties 49.65%. Support for safe food production of 42.50% and diversified techniques of 40.50% was limited. Adoption trends mirrored this: 69.31% used hybrid/improved seeds, 41.50% nutrient-rich varieties, and only 13.21% stress-tolerant varieties. Climate-smart practices were higher in Khulna (raised beds 83.33%, drip irrigation 61.40% than in Faridpur. Organic fertilizer use was higher in Khulna at 73.68% than in Faridpur at 48.48%. Post-harvest safe transport was 90.81%, but low-cost storage of 22.08% and traditional preservation of 17.45% were limited. Overall, 83.98% of households reported the availability of agricultural inputs, and 78.90% confirmed access in the input supply chain. Agro-input companies are driving both productivity and nutrition outcomes, while also highlighting the need to expand support for stress-tolerant varieties, storage innovations, and sustainable pest

Commented [A10]: Conclusion should be more precised. This is not the section to repeat the same results again here. These private companies are from BD or abroad, are they approved by the BD Govt? Do they provided services to the whole country, All these needd to be incorporated here. Then a clear picture will be available on the present research. What specific data were collected from the previous research or from the data base available? Clear all these.

management. Strengthened partnerships among agro-input providers, government agencies, and development actors are essential to scaling these impacts and ensuring long-term improvements in nutritious food production and consumption in southern Bangladesh.

5. RECOMMENDATION

- Agro-input companies should expand training on diversified production techniques, stress-tolerant varieties, and safe food practices, which showed relatively low farmer uptake despite their importance for nutrition and climate resilience.
- Promoting stress-tolerant seed varieties and water-efficient technologies like drip irrigation should be scaled up through targeted awareness campaigns, demonstration plots, and farmer field schools.
- Support should be provided for improved storage, preservation, and value addition techniques to reduce food loss and extend the shelf life of vegetables.
- Increase promotion of biological control methods by ensuring affordable supply and farmer training, reducing reliance on chemical pesticides, and improving food safety.
- Promote cost-efficient digital vegetable production technologies to produce nutritious foods and encourage commercialization.
- Improved input access through subsidies, last-mile distribution, and collaboration with local cooperatives, ensuring smallholders, women, and marginalized farmers benefit equally.
- Joint initiatives between agro-input companies, government, and NGOs can enhance household awareness on dietary diversity, boosting the consumption of nutritious foods.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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