International Journal of Agriculture and Food Science 2026; 8(8): 474-480

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(8): 474-480
www.agriculturaljournals.com
Received: 02-06-2026
Accepted: 07-07-2026

Tapash Kumar Bhowmik
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Minhajur Rahman
Ecology and Phytochemistry Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Md. Abul Kashem
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Sujan Rudra
Department of Statistics, University of Chittagong, Chattogram-4331, Bangladesh

Md. Abdul Alim
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Abu Taum
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Priota Datta Orpa
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Mira Barua
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Mohammad Mijanur Rahman
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Chayan Kumer Saha
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Corresponding Author:
Tapash Kumar Bhowmik
Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh

Impacts of high-value fruits and crops cultivation on agriculture and rural livelihoods: A comparative endline assessment of farming practices, technology adoption, and market access in Chattogram, Bangladesh

Tapash Kumar Bhowmik, Minhajur Rahman, Md. Abul Kashem, Sujan Rudra, Md. Abdul Alim, Abu Taum, Priota Datta Orpa, Mira Barua, Mohammad Mijanur Rahman and Chayan Kumer Saha

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i8f.1802

Abstract
The structural transition from subsistence farming to commercialized horticulture represents a critical pathway for rural economic transformation. A comparative assessment of the endline impacts (2025) of the RMTP-YPSA "High Value Fruit and Crops Varieties Extension and Marketing Sub-Project" in Chattogram, Bangladesh were evaluated. Beneficiary farmers demonstrated a massive shift from traditional cereal cultivation (90.10%) to climate-smart horticulture. Technology adoption emerged as a major differentiator: 50.40% of beneficiaries adopted drip irrigation (with 85.50% reporting reduced water use and 64.30% experiencing increased yields), 44.10% integrated IoT for farm management (vs. 4.17% control). Consequently, post-harvest losses was substantially lower; 42.80% of beneficiaries restricted losses to below 5%, whereas 41.60% of the control group suffered chronic losses between 11% and 25% due to a lack of cold storage (93.06%). Market integration also surged, with 87.00% of the treatment group using mobile networks for buyer contact and 55.20% securing a 6-10% price premium. These differences were accompanied by more favourable income, savings and market-access outcomes among beneficiary farmers. Nearly half (47.70%) of the beneficiary cohort achieved a primary monthly income of 10,001-20,000 BDT, effectively escaping the lowest income (<5,000 BDT) which still traps 53.70% of the control group. Furthermore, 77.10% of beneficiaries accessed project facilitated micro loans, enabling 78.90% to expand their orchards and culminating in newly increased household savings for 67.90% (vs. 25.00% control). Finally, dietary diversity (MDD-W) improved significantly. While baseline data showed 52.80% of the population lacked Vitamin-A rich foods, project interventions shifted consumption habits; 37.90% of beneficiaries now consume high-value fruits weekly and 53.70% monthly, effectively bypassing prohibitive market costs (86.90%). Ultimately, integrating digital value chain innovation and targeted financial inclusion successfully catalyzes a sustainable transition to market oriented horticulture, significantly advancing SDG 2 and SDG 3.

Keywords: Agricultural value chains, climate-smart horticulture, high-value crops, farm management, rural economic transformation

1. Introduction

The macroeconomic and agricultural landscape in South Asia is undergoing a vital structural transformation, pivoting from a historical preoccupation with cereal grain self-sufficiency toward a highly diversified, market oriented system focused on high-value fruits and crops (HVFC) (Joshi *et al.*, 2004) [10]. In the context of Bangladesh, agriculture has historically accounted for the lion's share of rural employment and livelihood generation; yet its relative contribution to the national Gross Domestic Product (GDP) has experienced a steady proportional decline, maintaining a persistent and problematic gap between labor share and economic output (McCullough *et al.*, 2008) [14]. Persistent systemic barriers including declining soil fertility, extreme climate vulnerability, fragmented landholdings and highly asymmetrical market information have historically trapped rural smallholders in perpetual cycles of low yield subsistence farming. To systematically dismantle these barriers, national and international strategic policy frameworks have increasingly shifted toward agricultural diversification, acknowledging that crops such as fruits, spices and non-traditional vegetables possess the capacity to generate exponentially higher income per unit of land compared to traditional staple crops like rice and wheat (Weinberger and Lumpkin, 2007) [18].

The necessity for this strategic agricultural shift is particularly acute in the ecologically fragile and climatically volatile regions of the Chattogram district. In these coastal and hilly terrains, small and marginal farmers face escalating existential challenges from erratic rainfall patterns, coastal salinity intrusion and extreme temperature fluctuations, which collectively render traditional agricultural paradigms highly precarious (Arslan *et al.*, 2015; Ahmed *et al.*, 2025) [3, 1]. The rapid adoption of Climate-Smart Agriculture (CSA) encompassing micro-irrigation systems, stress tolerant crop varieties and digital farm management has therefore emerged as a non-negotiable imperative for sustaining agricultural productivity and ensuring rural food security (FAO, 2013; Lipper *et al.*, 2014) [5, 13]. However, the successful integration of such advanced technologies requires overcoming severe institutional voids, most notably the lack of accessible rural finance, disjointed value chains and inadequate post-harvest infrastructure (Jack, 2013; Reardon, 2015) [9, 17].

In direct response to these compounded systemic challenges, the "High Value Fruit and Crops Varieties Extension and Marketing Sub-Project" was implemented by YPSA under the Rural Microenterprise Transformation Project (RMTP) (Haggblade and Hazell, 2010) [6]. Operational since 2021 in the Sitakunda and Mirsarai upazilas of Chattogram, the project's strategic development objective is to foster the sustainable growth of HVFC value chains that exhibit high market demand and robust market linkages. By facilitating access to safe agricultural inputs, promoting Good Agricultural Practices (GAP), and integrating cutting-edge digital frameworks such as the Internet of Things (IoT) for product traceability, the intervention seeks to bridge the chasm between subsistence farming and commercialized agribusiness.

The primary objective of this manuscript is to provide an exhaustive, data driven comparative assessment of the endline evaluation (2025) data, rigorously evaluating the differential outcomes between project beneficiary farmers (comprising the treatment group in Sitakunda and Mirsarai upazila) and non-beneficiary farmers (comprising the control group in Hathazari upazila). By systematically examining quantitative metrics across farming practices, technology adoption rates, market integration, economic transformation and nutritional outcomes, this study aims to elucidate the precise mechanisms through which targeted horticultural interventions drive rural prosperity and socioeconomic resilience.

2. Methodology

To comprehensively evaluate the multi-dimensional associated with the high-value fruit and crops extension and marketing sub-project, a rigorous, mixed-methods research design was deployed for the 2025 Endline Evaluation. The study employed a comparative analytical framework, assessing the performance and behavioral shifts of treatment group participants against a carefully selected non-intervention control group. This approach was designed to isolate the programmatic effects of the RMTP-YPSA initiative from broader macroeconomic or regional agricultural trends.

The research was geographically bounded to the Chattogram district of Bangladesh, targeting specific agro-ecological zones suitable for high-value horticulture. The treatment group consisted exclusively of active project beneficiaries located within the Sitakunda upazila and the Mirsarai upazila. Within Sitakunda, the sampled population was drawn from eight distinct unions: Bariyardhala (18.00%), Sitakund Sadar (10.80%), Muradpur (10.50%), Barbakund (3.30%), Banshbaria (6.60%), Bara Kumira (8.30%), Sonaichari (4.40%) and Bhatiari (3.90%). Within Mirsarai, participants were drawn from three unions: 9 no. Mirsarai (11.40%), 12 no. Khaiyachara (7.50%) and 15 no. Wahedpur (15.20%). Cumulatively, Mirsarai accounted for 34.30% of the beneficiary sample, while Sitakunda accounted for 65.70%. The control group was established in the adjacent Hathazari upazila, which shares similar topographical, agro-ecological and socio-demographic baselines but remained outside the RMTP-YPSA intervention perimeter. The control sample was drawn from 11 no. Fatehpur (49.00%), 1 no. Chatogram City Corporation area (29.20%) and 12 no. Chikomdondi (20.80%) union.

A statistically robust sampling methodology was utilized to ensure the representativeness, validity and reliability of the quantitative data extraction. The sample size was mathematically determined using the Cochran formula for categorical data in finite populations (6,038); yielding a total of 433 surveyed households. This cohort was subsequently stratified into 361 beneficiary households representing the treatment group and 72 non-beneficiary households representing the control group. The disproportionate stratification deliberately reflects the project's targeted outreach density and high programmatic penetration in the intervention zones, while maintaining a statistically significant and highly valid control baseline for comparative variance analysis.

The data collection architecture integrated both expansive quantitative surveys and nuanced qualitative participatory tools, administered during an intensive field deployment between September to October 2025. Structured, pre-tested quantitative household questionnaires were deployed utilizing digital data collection modalities to capture granular micro level data. The variables measured included socio-demographics, primary and secondary income shifts, technology adoption rates, irrigation utilization, post-harvest loss estimations and nutritional indicators specifically leveraging the Minimum Dietary Diversity for Women (MDD-W) and Household Dietary Diversity Score (HDDS) as recommended by the Food and Agriculture Organization (FAO).

3. Results

3.1 Data presentation and comparative analysis

The statistical findings delineate a comprehensive and striking comparative matrix between the RMTP-YPSA beneficiary farmers and the non-beneficiary farmers. The empirical results are systematically categorized into five core developmental domains: farming practices and productivity metrics, technology adoption rates, market access and value chain data, economic transformation and livelihood metrics and nutritional outcomes.

3.2. Farming practices and productivity metrics

An analysis of the socio-demographic baseline indicates a predominantly male agrarian demographic; however, the treatment group successfully integrated female participation, registering 16.90% female and 83.10% male respondents compared to an entirely male (100.00%) control group cohort. A distinct divergence is immediately evident in historical crop diversification and the foundational agricultural requirements prioritized by the farmers. Historically, both cohorts were heavily reliant on traditional cereal monoculture and standard subsistence vegetable farming. Specifically, 90.10% of the beneficiary farmers and 87.10% of the control farmers reported previously cultivating rice as their primary crop, while 81.60% and 80.00% cultivated standard vegetables, respectively. Only 17.80% of beneficiaries and a mere 7.10% of the control group had previously maintained dedicated fruit orchards, highlighting the baseline lack of high-value horticultural penetration prior to project interventions.

The transition toward high-value horticulture reveals sharp behavioral contrasts, particularly regarding the sourcing and quality assurance of foundational agricultural inputs (Fig. 1). While basic visual inspection for healthy saplings remains a dominant practice across both agricultural groups (77.40% for the Treatment group versus 90.30% for the Control group), the beneficiary cohort exhibited a significantly higher and systematic reliance on institutional and modern procurement channels. Over half (52.30%) of the beneficiary farmers sourced critical inputs directly from trusted government institutions, compared to a nominal 10.00% of the control group. Furthermore, 53.70% of beneficiaries verified input quality through registered institutions, compared to only 25.00% in the control cohort. Notably, 16.20% of the beneficiary farmers utilized emerging online and mobile platforms for input sourcing, a modernized practice that was entirely absent (0.00%) within the control group.

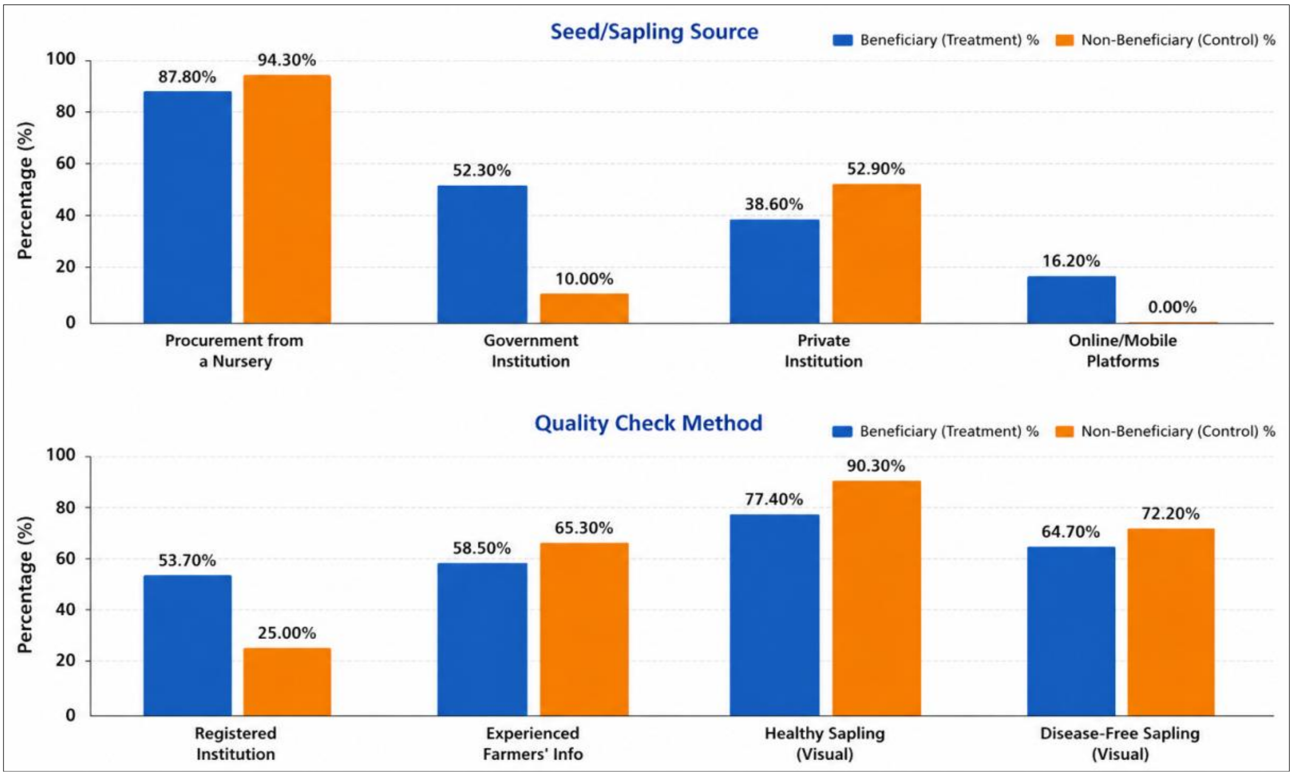

Fig 1: Comparison of seed/sapling procurement sources and quality-check methods between Beneficiary and Non-Beneficiary groups

Regarding fundamental cultivation requirements for HVFC, capital was universally recognized as the primary systemic constraint (94.60% for Treatment; 94.40% for Control). However, control group farmers reported a near-total dependency on acquiring basic training (98.80%) and acquiring fertilizers and machinery (96.30%), whereas the beneficiary needs were slightly more distributed (training at 81.40%, fertilizer/machinery at 85.60%). This variance reflects an ecosystem within the treatment zone that is already partially saturated with foundational agronomic knowledge and subsidized inputs through sustained project support.

3.3. Technology adoption rates

The active adoption of modern agricultural and climate resilient technologies emerged as the most defining statistical differentiator between the two cohorts. The project intervention heavily emphasized the integration of precision agriculture, resulting in overwhelming technological asymmetries that directly impacted farm level productivity and environmental sustainability.

For the treatment group, modern irrigation deployment was highly successful and pervasive (Table 1). About 50.40% of beneficiaries utilized drip irrigation exclusively, 9.60% utilized sprinkler systems and 9.90% utilized a combination of both technologies. The reported benefits of these precision irrigation systems among beneficiaries were substantial and multi-faceted: 85.50% reported vastly reduced water use, 64.30% reported directly increased crop yields and 54.10% reported a reduction in manual labor costs.

Table 1: Comparison of technology adoption and modern farming practices between beneficiary and non-beneficiary farmers in high-value fruit and crop cultivation.

Technology / Practice	Specific Application	Beneficiary (Treatment)%	Non-Beneficiary (Control)%
Irrigation systems	Drip irrigation systems	50.40%	-
	Sprinkler irrigation	9.60%	-
	Both drip and sprinkler	9.90%	-
	No modern irrigation	30.00%	-
Digital integration	Iot for farm management	44.10%	4.17%
	Crowd funding platforms	33.00%	6.94%
	Block chain (traceability)	30.90%	9.72%

Furthermore, frontier digital technologies were rapidly assimilated by the treatment cohort to optimize agribusiness operations. The Internet of Things (IoT) for precision farm management was adopted by 44.10% of beneficiaries, compared to a highly negligible 4.17% of the control group. Block chain technology, strategically intended to secure supply chain traceability and facilitate quality certification (such as Global GAP, which was reported as a received project support by 61.10% of beneficiaries), was adopted by 30.90% of beneficiaries versus a mere 9.72% of the control group. Due to the synergistic application of these improved technological interventions, alongside guided bio-fertilizer and bio-pesticide applications, plant mortality and cultivation losses dramatically decreased for beneficiaries. Specifically, 41.70% of the treatment group reported a 5-10% reduction in plant mortality and an additional 43.30% reported a highly significant 15-25% reduction in crop loss.

3.4. Market access and value chain data

Integration into formal domestic and export markets, coupled with the structural management of post-harvest value chains, highlights a definitive transition from informal, ad-hoc selling to structured, resilient agribusiness. Beneficiary farmers revolutionized their buyer communication and marketing channels; 87.00% utilized mobile networks to maintain buyer contact, 44.10% utilized social media platforms and crucially, 20.40% successfully engaged in formal, legally binding contracts with buyers. Conversely, the control group remained trapped in informal market dynamics, relying significantly less on mobile communication (36.08%), social media (8.25%) and formal contractual agreements (7.22%).

Post-harvest management historically a chronic vulnerability in South Asian horticulture demonstrated remarkable and quantifiable improvement among project beneficiaries. The empirical data confirms that Beneficiary farmers reported a substantially lower prevalence of severe post-harvest losses than non-beneficiary farmers (Table 2). A highly favorable 42.80% of beneficiaries managed to keep their post-harvest losses below 5%. Only 7.50% of beneficiaries experienced severe post-harvest losses in the 11-25% range, compared to a staggering 41.60% of the non-beneficiary control group. When assessing the underlying systemic causes of spoilage, both groups cited significant constraints, but the control group was overwhelmingly crippled by infrastructural deficits: 93.06% cited a critical lack of fruit storage, compared to 77.70% of beneficiaries. To physically preserve harvested fruits, 75.60% of beneficiaries still rely on normal ambient temperature storage, but an encouraging 21.50% have successfully accessed local cold storage infrastructure, while 50.70% utilize immediate same-day sales strategies to proactively bypass storage requirements altogether.

Table 2: Post-harvest losses and major causes of spoilage among beneficiary and non-beneficiary farmers

Value Chain Metric	Category / Outcome	Beneficiary (Treatment)%	Non-Beneficiary (Control)%
Estimated post-harvest loss	Less than 5% loss	42.80%	18.10%
	5% - 10% loss	49.10%	40.30%
	11% - 25% loss	7.50%	41.60%
Primary causes of spoilage	Lack of advanced harvesting technology	82.30%	81.94%
	Lack of fruit storage facilities	77.70%	93.06%
	Lack of processing facilities	78.00%	76.39%

3.5. Economic transformation and livelihood metrics

The successful integration of high-value agriculture, modern operational technology and direct market access culminated in definitive and transformative economic disparities between the two groups. Financial health, capital accumulation and raw household income shifted dramatically and uniformly in favor of the beneficiary cohort (Table 3). An analysis of primary occupation monthly income highlights a highly successful upward socio-economic transition: nearly half (47.70%) of the beneficiary farmers now consistently earn between 10,001 and 20,000 BDT, effectively escaping the lowest extreme poverty income bracket which still traps a severe 53.70% of the control group (earning less than 5,000 BDT). Following the adoption and cultivation of HVFC, 54.20% of the treatment group reported a moderate 11-25% increase in total household income and 14.10% reported a massive 26-50% increase. This income surge directly correlates to the surge in HVF sales volume (with 59.90% of beneficiaries reporting a 11-25% sales volume increase) and vastly improved market price realization (with 55.20% realizing a 6-10% price premium on their crops).

Table 3: Economic indicators of beneficiary and non-beneficiary households

Economic Indicator	Bracket / Outcome	Beneficiary (Treatment)%	Non-beneficiary (Control)%
Monthly income (Main occupation)	Less than 5,000 BDT	7.80%	53.70%
	5,001 - 10,000 BDT	29.00%	29.50%
	10,001 - 20,000 BDT	47.70%	12.60%
	Above 20,000 BDT	15.50%	4.20%
Changed economic condition	Better access to capital	69.90%	33.30%
	Increased savings	67.90%	25.00%
	Asset creation	39.00%	20.80%
	No significant change	1.40%	50.00%

Financial inclusion was directly and deliberately facilitated by the project ecosystem. A highly significant 77.10% of beneficiaries received necessary capital loans directly through the project under distinct, tailored microfinance products (Buniyad 37.90%, Sufal 35.50%, Jagoran 29.40%, OBA 9.70%). Consequently, 78.90% of beneficiaries utilized these targeted loans to physically expand their orchards or landholdings and 68.00% utilized the liquidity to purchase advanced agricultural inputs. The socio-economic resilience generated by this directed financial liquidity is overwhelmingly evidenced by the 67.90% of beneficiaries reporting newly increased household savings, compared to a mere 25.00% in the control group. Conversely, a staggering 50.00% of the control group reported absolutely no change in their overall economic condition, compared to only 1.40% of the treatment group reporting stagnation.

3.6 Nutritional outcome (MDD-W and HDD)

The economic upliftment generated by horticultural commercialization created a powerful ripple effect on household dietary diversity and nutritional security. The endline evaluation specifically measured the Minimum Dietary Diversity for Women (MDD-W) alongside overall household consumption patterns. While baseline historical data revealed severe regional dietary deficiencies specifically noting that 52.80% of the regional population lacked adequate Vitamin-A rich fruits and vegetables the endline data demonstrated a marked behavioral shift in the consumption of high-value, nutrient-dense crops among beneficiaries.

4. Discussion

The endline data illustrates that the project intervention was associated with rural economic transformation. Interpreting the divergence between treatment and control groups through global and regional agricultural economics reveals several themes regarding productivity, climate resilience, supply chains and socio-economic empowerment.

4.1 Shift in farming practices

Transitioning from low yield staple crops to high-value fruit and crop (HVFC) farming requires overcoming structural inertia. Over 87% of both groups historically cultivated rice, driven by caloric food security policies and a lack of alternative knowledge (Pingali, 2012) [16]. Cereal production on fragmented landholdings traps smallholders in low-income equilibria (Weinberger and Lumpkin, 2007) [18]. The project intervention de-risked this transition by providing technical training (94.40% of beneficiaries) and institutionalized sapling verification. The control group's reliance on visual checks (90.30%) versus the treatment group's systematic reliance on registered institutional verification (53.70%) underscores a shift to scientifically backed horticulture. Successful integration requires such institutional risk mitigation (Birthal *et al.*, 2013) [4]. Formalizing the input supply chain may have addressed the barrier of poor genetic material, driving the beneficiaries' higher yields.

4.2 Dynamics of climate smart agriculture

In coastal Chattogram, salinity and erratic rainfall render conventional farming vulnerable (Arslan *et al.*, 2015; Ahmed *et al.*, 2025) [3, 1]. The 50.40% adoption rate of drip irrigation among beneficiaries stands in stark contrast to the control group, representing a leap in resource efficiency. Market inefficiencies and capital costs typically prohibit technology adoption (Jack, 2013) [9]. However, the project may have reduced these barriers by intertwining subsidized loans (77.10% of beneficiaries) with hands-on technological provision. The outcomes 85.50% experiencing reduced water use and 64.30% increasing yields align with evidence that precision irrigation optimizes nutrient delivery and insulates farmers from shocks (Kassie *et al.*, 2008; FAO, 2013) [11, 5]. Promoting bio-fertilizers and Integrated Pest Management (IPM) further fostered a transition away from agrochemical dependency.

4.3 Impact of value chain digitization

Digitizing the value chain resolves "hidden middle" inefficiencies (Reardon, 2015) [17]. The control group's severe post-harvest losses (41.60% experiencing 11-25% loss) reflect disjointed supply chains, asymmetric information and absent cold storage. Beneficiaries bypassed these deficits through digital integration. IoT for farm management (44.10%) and Block chain (30.90%) enabled supply chain traceability and Global GAP certification. Digitization of direct market linkages (87.00% via mobile, 44.10% via social media) neutralized storage deficits. Economic upgrading fundamentally requires direct producer-to-buyer linkages (Humphrey and Schmitz, 2002) [7]. By organizing Producer Marketing Groups (PMGs), the project compressed the supply chain, ensuring that 55.20% of farmers realizing a 6-10% price premium retained those margins instead of losing them to intermediaries.

4.4 Socio-economic resilience

The ultimate test of agricultural intervention is socio-economic resilience. Data confirms a structural economic elevation, with 47.70% of beneficiaries catapulting into the 10,001-20,000 BDT monthly income bracket. Reinvestment is evident: 69.90% reported better access to capital and 39.00% achieved tangible asset creation, shifting from subsistence survival to wealth generation. This empowerment is vital for rural youth and marginalized smallholders. Microcredit designed for agro-enterprise expansion generated a self-sustaining engine of growth. Localized prosperity heavily depends on the synergistic relationship between crop income and the broader rural non-farm economy (Haggblade and Hazell, 2010) [6]. Heavily increased savings (67.90%) act as a vital buffer, enhancing community resilience and actively mitigating rural-to-urban migration (IFAD, 2019) [8].

4.5 Agricultural impact on nutrition

Higher incomes do not automatically equate to better diets without targeted nutritional awareness (Pingali, 2015) [15]. The project bridged this gap using the Minimum Dietary Diversity for Women (MDD-W) indicator. By transitioning farmers into producers of Vitamin A-rich fruits (e.g., mango, papaya), the intervention addressed the 52.80% regional population baseline deficiency. The increased HVF consumption frequency (37.90% weekly among beneficiaries versus 25.00% in control) demonstrates a dual benefit: profitable commercial surplus alongside micronutrient-rich domestic retention. This aligns with findings that smallholder horticultural diversification effectively combats hidden hunger and improves rural nutritional outcomes (Arimond and Ruel, 2004; Kennedy *et al*., 2011) [2, 12].

5. Conclusion

The endline evaluation of the "High Value Fruit and Crops" sub-project confirms its success as a highly replicable blueprint for sustainable rural economic transformation in Bangladesh. By systematically replacing traditional subsistence farming with a technology driven horticultural framework, the initiative facilitated profound socio-economic growth in the Chattogram region. The comparative data indicates that synergized interventions including climate-smart technologies (precision irrigation), digital market integration (IoT, Block chain) and tailored microfinance generate immense macroeconomic dividends. Beneficiary farmers vastly outperformed the control cohort across all operational metrics, achieving drastically reduced post-harvest losses, superior market price realization and substantial upward mobility in household income. Crucially, this localized financial prosperity cascaded directly into enhanced dietary diversity (MDD-W). By integrating scientific research, digital value chain innovation and inclusive financial access, the project model empowers smallholders and cultivates long-term resilience. Ultimately, this scalable paradigm makes direct, quantifiable contributions to the United Nations Sustainable Development Goals of Zero Hunger (SDG 2) and Good Health and Well-being (SDG 3).

6. Declaration

Acknowledgement

The authors would like to express their sincere appreciation and profound gratitude to Md. Arifur Rahman, Chief Executive; Md. Manzur Murshed Chowdhuri, Director of Economic Development; Md. Newaz Mahmud, Program Manager; and Mr. Suman Deb Nath, Project Manager, YPSA, Chattogram, for their invaluable guidance, encouragement, financial support, and generous assistance, which contributed significantly to the successful completion of the endline survey.

The authors also extend their deep appreciation to Akond Md. Rafiqul Islam, Senior General Manager, PKSF, Dhaka, Bangladesh, for his constructive guidance and valuable support throughout the field investigation and data collection process.

The authors are sincerely thankful to all the participating farmers from Sitakunda and Mirsarai upazilas of Chattogram for sharing authentic and valuable information.

Furthermore, the authors gratefully acknowledge the dedicated contributions of the enthusiastic students Rokeya Akter Rita, Shahriar Arafat, Md. Shakhawat Hossain, Tama Bhowmik, Ummay Sayeda Tabassum, Georgia Chakma, Suranjona Tripura and U Khai Wai Marma from the Department of Botany, University of Chittagong, for their valuable support in data collection and data entry. Special appreciation is also extended to Md Delowar Hossen, Project Assistant, Endline Evaluation of High-Value Fruits and Crops Extension and Marketing Sub-Project, Chattogram, Bangladesh.

Finally, the authors gratefully acknowledge the Plant Tissue Culture and Biotechnology Laboratory, Department of Botany, Faculty of Biological Sciences, University of Chittagong, Chattogram-4331, Bangladesh, for providing the laboratory facilities required to carry out and successfully complete this research.

Conflict of Interest

The authors confirm that they have no commercial or financial affiliations that could be regarded as a potential conflict of interest related to this research.

Funding Statement

This endline assessment received financial support through the Rural Microenterprise Transformation Project (RMTP), with additional support provided by YPSA, Chattogram.

Data availability statement

The datasets generated and analyzed during this study are not publicly accessible because of participant privacy and confidentiality concerns; however, they are available from the corresponding author upon reasonable and justified request.

References

1. Ahmed S, Debnath M, Haque A, Bhandari H. Transforming Bangladesh's coastal agriculture needs bridging innovation with policy action. International Rice Research Institute. 2025;1(1):1-13.
2. Arimond M, Ruel MT. Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. Journal of Nutrition. 2004;134(10):2579-2585.
3. Arslan A, McCarthy N, Lipper L, Asfaw S, Cattaneo A, Kokwe M. Climate smart agriculture? Assessing the adaptation implications in Zambia. Journal of Agricultural Economics. 2015;66(3):753-780. DOI:10.1111/1477-9552.12107.
4. Birthal PS, Joshi PK, Roy D, Thorat A. Diversification in Indian agriculture towards high-value crops: the role of smallholders. Canadian Journal of Agricultural Economics. 2013;61(1):61-91. DOI:10.1111/j.1744-7976.2012.01258.
5. FAO. Climate-smart agriculture sourcebook. Rome: Food and Agriculture Organization of the United Nations; 2013.

6. Haggblade S, Hazell PBR. Successes in African agriculture: lessons for the future. Baltimore: Johns Hopkins University Press; 2010.
7. Humphrey J, Schmitz H. How does insertion in global value chains affect upgrading in industrial clusters? Regional Studies. 2002;36(9):1017-1027.
8. IFAD. Rural development report 2019: creating opportunities for rural youth. Rome: International Fund for Agricultural Development; 2019.
9. Jack BK. Market inefficiencies and the adoption of agricultural technologies in developing countries. Agricultural Economics. 2013:1-58.
10. Joshi PK, Gulati A, Birthal PS, Tewari L. Agriculture diversification in South Asia: patterns, determinants and policy implications. Economic and Political Weekly. 2004;39(24):2457-2468.
11. Kassie M, Zikhali P, Manjur K, Edwards S. Adoption of organic farming technologies: evidence from a semi-arid region in Ethiopia. Gothenburg: School of Business, Economics and Law, University of Gothenburg; 2008. p. 1-18.
12. Kennedy G, Ballard T, Dop MC. Guidelines for measuring household and individual dietary diversity. Rome: Food and Agriculture Organization; 2011.
13. Lipper L, Thornton P, Campbell BM, Baedeker T, Braimoh A, Bwalya M, *et al*. Climate-smart agriculture for food security. Nature Climate Change. 2014;4(12):1068-1072. DOI:10.1038/nclimate2437.
14. McCullough EB, Pingali PL, Stamoulis KG. The transformation of agri-food systems: globalization, supply chains and smallholder farmers. Rome: Food and Agriculture Organization of the United Nations; 2008.
15. Pingali PL. Agricultural policy and nutrition outcomes: getting beyond the preoccupation with calories. Food Security. 2015;7(3):583-591.
16. Pingali PL. Green revolution: impacts, limits and the path ahead. Proceedings of the National Academy of Sciences. 2012;109(31):12302-12308. DOI:10.1073/pnas.0912953109.
17. Reardon T. The hidden middle: the quiet revolution in the midstream of agrifood value chains in developing countries. Oxford Review of Economic Policy. 2015;31(1):45-63. DOI:10.1093/oxrep/grv011.
18. Weinberger K, Lumpkin TA. Diversification into horticulture and poverty reduction: a research agenda. World Development. 2007;35(8):1464-1480. DOI:10.1016/j.worlddev.2007.05.002.