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Institutional Roles and Farmer Acceptance in Agricultural Technology Transfer: A Multi-Stakeholder Framework in Nueva Ecija, Philippines

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Abstract: This study explores the interplay between institutional roles and farmer acceptance in agricultural technology transfer in Nueva Ecija, Philippines. Employing a mixed-methods approach, quantitative data were gathered through surveys with 50 farmers to assess acceptance of agricultural technologies in terms of perceived usefulness, ease of use, cost implications, and accessibility. Complementary qualitative data were collected through Focus Group Discussions (FGDs) with representatives from universities (NEUST, CLSU), government agencies (DA, ATI, LGUs), private enterprises, and farmer cooperatives to examine institutional roles, challenges, and gaps in technology transfer. Descriptive statistics and thematic analysis were applied to interpret the data.

The findings indicate that farmers show a high level of acceptance of agricultural technologies, with perceived usefulness (M = 4.32) identified as the strongest driver of adoption. However, cost implications (M = 3.42) emerged as a major barrier, highlighting the need for financial support mechanisms such as subsidies, cooperative-based equipment sharing, and rental schemes. Institutional analysis revealed that universities and government agencies lead knowledge dissemination and extension services, private enterprises play a key role in commercialization, and cooperatives facilitate community-level adoption. Key challenges include policy misalignment, limited infrastructure, insufficient funding, and weak institutional coordination.

Based on these findings, a Multi-Stakeholder Collaborative Framework was developed, combining the strengths of universities, research centers, government agencies, private enterprises, and farmer cooperatives. Grounded in the Triple Helix Model and Technology Acceptance Model (TAM), this framework promotes shared responsibilities to improve affordability, accessibility, and sustainability in agricultural technology transfer.

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I. INTRODUCTION

Agriculture remains a vital sector in the Philippines, not only as a source of livelihood but also as a cornerstone of national food security. However, the sector continues to face challenges such as fluctuating productivity, climate variability, labor shortages, and global market competition. The government and research institutions in the Philippines have recently intensified efforts in technology transfer, focusing on translating innovations generated through research and development (R&D) into tangible, on-the-ground applications for farmers and agro-enterprises" (Department of Science and Technology, 2024). In the Philippines, programs under the Department of Agriculture such as the National Technology Transfer and Commercialization Program and the Philippine Digital Agriculture Strategy highlight the government's commitment to establishing effective channels where State Universities and Colleges (SUCs), government agencies, and private stakeholders can bring modern technologies directly to farmers (Department of Agriculture, 2023; Department of Agriculture – Bureau of Agricultural Research & International Rice Research Institute [DA-BAR & IRRI], 2024). Despite ongoing government and institutional initiatives, technology transfer in Philippine agriculture remains uneven, often hindered by limited extension services, inadequate farmer training, and persistent gaps between institutional innovations and farmer-level acceptance (Inutan et al., 2025; Enario & Bugao, 2025).

Within this national framework, Nueva Ecija serves as a critical locus for technology transfer in agriculture. Known for its extensive rice production, the province is home to several major agricultural and research institutions, including state universities, research centers, and farmer cooperatives that actively drive technological advancements and innovation in farming. Institutions such as Nueva Ecija University of Science and Technology (NEUST), Central Luzon State University (CLSU), the Philippine Rice Research Institute (PhilRice), and the Philippine Carabao Center (PCC) are at the forefront of developing, demonstrating, and transferring agricultural technologies. In 2022, the Department of Agriculture—in partnership with Central Luzon State University established the Precision and Digital Agriculture Center (PreDiC) in Muñoz, Nueva Ecija. Funded by DA-BAR, PreDiC serves as the first national facility dedicated to institutionalized technology transfer, piloting digital platforms, precision farming tools, drone-assisted operations, GPS-guided tractors, and IoT-based irrigation systems (Department of Agriculture, 2022; Central Luzon State University, 2022).

Despite recent advancements, the challenge remains in bridging the gap between innovation development and grassroots adoption. Studies in the Philippines demonstrate that,

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although institutional efforts have increased farmer awareness of modern technologies, adoption continues to be constrained by high costs, low digital literacy, and the need for ongoing technical support (Food and Agriculture Organization, 2022; Davao Oriental State University et al., 2025).For instance, while specialized rice production technologies have been positively received through effective extension programs, many farmers remain hesitant to invest in such tools due to financial barriers and limited access to training (Mercado et al., 2025). This underscores that technology transfer must extend beyond mere availability. This demonstrates that technology transfer must go beyond dissemination it requires collaboration, capacity-building, and a strong feedback loop between institutions and farmers.

Current literature on agricultural modernization often addresses either institutional mechanisms of technology transfer (e.g., university commercialization ecosystems, policy frameworks) or farmer-level acceptance factors (e.g., perceived usefulness, digital literacy), with few studies integrating both perspectives. This fragmentation limits the design of holistic, scalable systems for technology transfer and commercialization in agricultural settings such as Nueva Ecija (Sarita & Inutan, 2025; Brown & Jensen, 2023).Addressing this gap requires analyzing how universities, government agencies, private enterprises, and farmer groups collectively influence the technology transfer process.

This study employs a mixed-methods approach to examine technology transfer from both the institutional and farmer perspectives. Using the Technology Acceptance Model (TAM), it measures farmer perceptions of usefulness, ease of use, accessibility, and cost, while focus group discussions (FGDs) with representatives from NEUST, CLSU, DA-ATI, private agribusinesses, and farmer cooperatives explore the Triple Helix interactions that shape technology dissemination and commercialization. Ultimately, this research aims to develop a collaborative framework that strengthens technology transfer and adoption in Nueva Ecija, ensuring that institutional innovations are effectively translated into farmer-led practices.

By situating this research in a province that plays a strategic role in agricultural productivity and innovation, the study contributes not only to the understanding of technology transfer mechanisms but also to the formulation of multi-stakeholder strategies that promote sustainable, inclusive, and farmer-driven modernization of agriculture in the Philippines.

II. MATERIALS AND METHODS

This study employed a mixed-methods approach to analyze technology transfer and farmer acceptance in Nueva Ecija, integrating both quantitative (survey-based) and qualitative (FGDs and stakeholder interviews) perspectives to provide a comprehensive understanding of institutional mechanisms and end-user responses (Ambong, 2022). The research was anchored on the Technology Acceptance Model (TAM), which measures user acceptance based on perceived usefulness and ease of use (Davis, 1989), and the Triple Helix Model, which examines the interactions among universities, government agencies, and private enterprises in driving innovation. A SWOT analysis was also applied to identify the strengths, weaknesses, opportunities, and threats of current technology transfer mechanisms.

A descriptive survey was conducted with 50 farmers selected via purposive sampling to measure acceptance levels in terms of perceived usefulness, ease of use, cost, and accessibility an approach consistent with established methodologies in agricultural technology adoption studies (Agussabti et al., 2022). Complementing this, focus group discussions (FGDs) were organized with representatives from NEUST, CLSU, DA-ATI, private agribusinesses, and farmer cooperatives to assess institutional roles, gaps in extension services, and collaboration strategies. Data collection instruments included a structured questionnaire for farmers and an FGD guide for institutional stakeholders.

Quantitative data were analyzed using descriptive statistics**,** while qualitative data from FGDs were subjected to thematic analysis**,** following established mixed-method research protocols in agricultural studies (Trushna et al., 2020). Findings from both data sets were integrated through triangulation to generate a comprehensive understanding of the interplay between institutional technology transfer initiatives and farmer acceptance, forming the basis for a proposed collaborative framework for improved adoption and commercialization.

III. RESULTS AND DISCUSSION

This section presents the results of the study, organized according to the specific research problems (SOP 1 to SOP 4). Quantitative data from 50 farmers were analyzed using mean scores**,** while qualitative data were obtained from Focus Group Discussions (FGDs) involving representatives from universities (NEUST, CLSU), government agencies (DA, ATI, LGU agriculturists), private enterprises, and farmer cooperatives. The quantitative results were interpreted based on the following scale: 4.21–5.00 = Very High; 3.41–4.20 = High; 2.61–3.40 = Moderate; 1.81–2.60 = Low; 1.00–1.80 = Very Low. Meanwhile, the institutional roles from FGDs were assessed using a 5-point scale where 1 = Strongly Disagree and 5 = Strongly Agree.

A. Farmers' Level of Acceptance of Agricultural Technologies

The level of farmers' acceptance of agricultural technologies in Nueva Ecija was assessed across four key factors: perceived usefulness, ease of use, cost implications, and accessibility. Table 1 provides a summary of the overall mean scores, interpretations, and highest-rated statements for each factor.

Table 1. Farmers' Level of Acceptance of Agricultural Technologies (N = 50)

Factor	Overall Mean	Interpretation	Highest-rated Statement (Mean)
Perceived Usefulness	4.32	Very High Acceptance	Technologies improve crop yield and quality (4.45)
Ease of Use	4.10	High Acceptance	Equipment is easy to operate (4.20)
Cost Implications	3.42	Moderate Acceptance	Maintenance and repairs are reasonably priced (3.50)
Accessibility	3.78	High Acceptance	Cooperative membership improves access (3.90)

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➢ *Perceived Usefulness*

Farmers strongly agree that agricultural technologies improve productivity and overall farm outcomes, with an overall mean of 4.32 (very high acceptance). The highest-rated item 'Technologies improve crop yield and quality' (M = 4.45) reflects farmers' recognition of mechanical dryers, transplanters, and rice milling tools as valuable innovations. This aligns with Mishra et al. (2024), who found that on farm demonstration programs significantly enhanced both technology adoption and farm yields, indicating that perceived productivity benefits are key drivers of farmers' willingness to adopt new agricultural tools. Caliguiran & Guingab, (2024) also emphasize that perceived usefulness is a key factor influencing technology adoption in the Philippine agricultural sector.

➢ *Ease of Use*

The ease of use of agricultural technologies was rated high (M = 4.10). Farmers indicated that most equipment, such as tractors and dryers, is simple to operate when paired with training provided by DA and SUCs. The highest-rated item was "Equipment is easy to operate" (M = 4.20), though digital platforms (e.g., e-Kadiwa) scored slightly lower (M = 4.05), indicating the need for additional guidance and digital literacy programs. According to the Technology Acceptance Model (TAM), ease of use significantly affects technology adoption (Davis, 1989), a finding also supported by Bang and Han (2025).

➢ *Cost Implications*

Cost remains a major barrier to adoption, with an overall mean of 3.42 (moderate acceptance). Farmers expressed that initial costs of modern equipment are high (M = 3.35), though they acknowledged that maintenance costs are relatively reasonable (M = 3.50). The findings resonate with Bautista et al., (2024), who reported that high capital costs discourage smallholder farmers from investing in advanced technologies despite their long-term benefits. Solutions such as government subsidies, rental schemes, and cooperative-based financing are necessary to improve affordability.

➢ *Accessibility*

Accessibility was rated high (M = 3.78), with "Cooperative membership improves access to equipment" scoring the highest (M = 3.90). Farmers recognize the role of cooperatives and SUC-led demonstration programs in ensuring access to modern tools and training. However, remote areas still face logistical constraints, which is consistent with FAO's (2023) observation that rural infrastructure gaps hinder technology adoption in Southeast Asia.

- *Synthesis of Findings*

Overall, farmers in Nueva Ecija exhibit high acceptance of agricultural technologies, with perceived usefulness (M = 4.32) emerging as the strongest factor. In contrast, cost implications (M = 3.42) remain the primary challenge, limiting the widespread adoption of these technologies. The results emphasize that effective technology transfer must go beyond dissemination by ensuring affordability, improving digital literacy, and providing accessible extension services (Briones et al., 2023).

B. Institutional Roles in Technology Transfer

Focus Group Discussions (FGDs) with representatives from universities (NEUST, CLSU), government agencies (DA, ATI, LGU agriculturists), private enterprises, and farm cooperatives highlighted their collective contributions to agricultural technology transfer. Their roles were examined in terms of knowledge dissemination, extension services, innovation support, and commercialization efforts.

Table 2. Institutional Roles in Technology Transfer (N = 10)

Factor	Overall Mean	Interpretation	Highest-rated Statement (Mean)
Knowledge Dissemination	4.30	Very Effective	Universities conduct research-based trainings (4.50)
Extension Services	4.11	Effective	Universities support farmer field schools (4.30)
Innovation Support	3.98	Effective	Universities assist farmer-led innovations (4.15)
Commercialization Efforts	4.03	Effective	Private enterprises distribute agri-tech tools (4.20)

➢ *Knowledge Dissemination*

Knowledge dissemination was rated very effective (M = 4.30), with universities and government agencies identified as the primary knowledge hubs. NEUST and CLSU were commended for organizing research-based seminars, demonstration farms, and online webinars. DA and ATI complement these efforts through information campaigns and technical manuals. Private enterprises and cooperatives also contribute but at a smaller scale, often focusing on product-specific information. This aligns with Briones et al. (2023), who emphasized that state universities and government agencies are the backbone of agricultural knowledge transfer in the Philippines.

➢ *Extension Services*

Extension services were rated effective (M = 4.11). Universities and government agencies lead initiatives like farmer field schools, demo farms, and technical support visits. Private enterprises provide after-sales service and tool-specific training, while cooperatives facilitate peer-to-peer learning. According to FAO (2023), such multi-institutional partnerships are essential to bridge the gap between research outputs and real-world application.

➢ *Innovation Support*

Innovation support was rated effective (M = 3.98) but requires greater collaboration in R&D and farmer-driven innovation. FGDs revealed that NEUST and CLSU have technology business incubators (TBI) and pilot projects, but awareness among farmers remains low. Private enterprises mainly test commercially viable technologies, often with limited farmer co-creation. This mirrors the findings of Bang and Han (2025), who stressed the need for inclusive innovation ecosystems where farmers are actively engaged in the innovation process.

➢ *Commercialization Efforts*

Commercialization efforts were also rated effective (M = 4.03), with private enterprises leading in the marketing and distribution of technologies. Cooperatives play a supportive role through bulk purchasing and shared services. Universities and government agencies provide linkages to funding programs and licensing support, although commercialization efforts remain slow due to weak marketing strategies and high product costs. This finding supports the view that stronger university–industry–government collaboration is essential to achieve sustainable commercialization of agricultural innovations (International Service for the Acquisition of Agri biotech Applications [ISAAA], 2024).

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- *Synthesis of Findings*

Overall, the FGDs indicate that universities and government agencies dominate knowledge dissemination and extension services, private enterprises excel in commercialization, and cooperatives support access and peer learning. However, innovation support and commercialization efforts require improved synergy and coordination to create a more cohesive technology transfer system. These insights reflect the Triple Helix model's emphasis on sustained collaboration between universities, government, and industry (Etzkowitz & Zhou, 2017).

C. Challenges and Gaps in Technology Transfer

Challenges and gaps in agricultural technology transfer were evaluated through FGDs with 10 institutional stakeholders (universities, government agencies, private enterprises, and farmer leaders). The assessment focused on policy support, infrastructure readiness, farmer readiness, and institutional collaboration.

Table 3. Challenges and Gaps in Technology Transfer (N = 10)

Factor	Overall Mean	Interpretation	Key Challenge (Mean)
Policy Support	3.14	Moderate Challenge	Misalignment of national and local policies (3.20)
Infrastructure Readiness	3.33	Moderate Challenge	Lack of training and demo infrastructure (3.60)
Farmer Readiness	3.09	Moderate Challenge	Low financial readiness for agri-tech (2.85)
Institutional Collaboration	3.04	Moderate Challenge	Inefficient farmer feedback loops (2.95)

- *Policy Support*

Policy support recorded a moderate challenge rating (M = 3.14). Although frameworks like the Philippine Agricultural and Fisheries Modernization Act (AFMA) support modernization, stakeholders cited insufficient funding for farmer training and subsidies and poor alignment of local and national initiatives. This finding supports evidence that policy fragmentation can slow the scale-up of agri tech adoption, particularly when overlapping mandates across research and extension institutions create confusion, inefficiencies, and uneven adoption outcomes (Philippine Institute for Development Studies, 2021).

- *Infrastructure Readiness*

Infrastructure readiness was rated moderate (M = 3.33), with training and demonstration facilities (M = 3.60) identified as the most pressing gap. Limited post-harvest facilities, storage, logistics, and internet connectivity hinder the full implementation of digital agriculture solutions. Transforming Agricultural Extension Services in Southeast Asia, RASSEA (2025) similarly emphasized that digital farming systems require robust infrastructure to be sustainable in rural settings.

- *Farmer Readiness*

Farmer readiness posed a moderate challenge (M = 3.09), particularly due to low financial capacity to invest in modern equipment (M = 2.85). While attitudes toward adopting new tools are positive (M = 3.40), knowledge gaps and limited access to affordable credit remain barriers. Mercado et al. (2025) reported similar issues among smallholder farmers in Nueva Ecija, underscoring the need for more targeted extension programs and financing schemes.

- *Institutional Collaboration*

Institutional collaboration was rated moderate (M = 3.04). Stakeholders cited weak coordination and limited public-private partnerships, as well as inadequate feedback loops from farmers to research institutions (M = 2.95). Although the Triple Helix model calls for close synergy between universities, government, and industry (Etzkowitz & Zhou, 2017), siloed operations persist. Addressing this requires joint funding programs, collaborative R&D, and active farmer engagement.

- *Synthesis of Findings*

The results indicate that policy, infrastructure, farmer readiness, and institutional collaboration are all moderate challenges to effective technology transfer. While individual programs exist, they are hindered by fragmented implementation, insufficient funding, and limited coordination. These findings echo Ben Farah & Amara (2025) which emphasize that technology transfer thrives when policy support, infrastructure readiness, and farmer capacity are fully aligned and mutually reinforced.

D. Collaborative Framework for Agri-Tech Transfer and Farmer Adoption

Based on the findings from SOP 1 (farmers' acceptance levels), SOP 2 (institutional roles), and SOP 3 (challenges and gaps), this framework was developed to strengthen agri-tech transfer and adoption. It integrates the collective strengths of universities, government agencies, research and innovation centers, private enterprises, and farmer communities to create a seamless technology transfer system. Grounded in the Triple Helix Model (Etzkowitz & Zhou, 2017) and the Technology Acceptance Model (TAM), the framework ensures that collaborative efforts focus on farmers' key needs usefulness, ease of use, cost-effectiveness, and accessibility.

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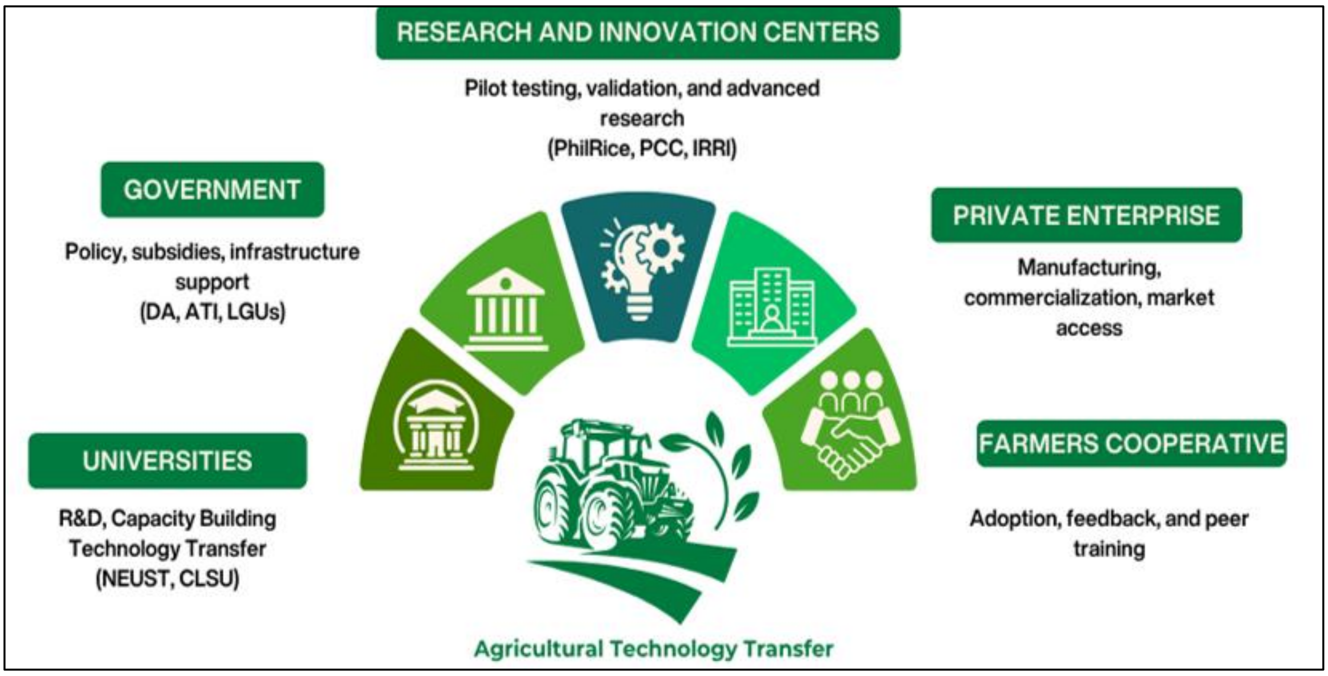

Fig 1. Multi-Stakeholder Collaborative Framework for Agricultural Technology Transfer

The proposed framework emphasizes shared responsibilities and mutual reinforcement among five key sectors to ensure effective agri-tech transfer and adoption. Universities (NEUST, CLSU) function as innovation hubs, leading R&D, technology transfer, and capacity-building programs. Research and Innovation Centers (PhilRice, PCC, IRRI) specialize in pilot testing, validation, and advanced research that inform scalable solutions. Government agencies (DA, ATI, LGUs) provide policy support, subsidies, and infrastructure development, ensuring an enabling environment for technology dissemination. Private enterprises drive manufacturing, commercialization, and market access, while farmer cooperatives facilitate community-level adoption, feedback, and peer training.

The framework addresses barriers identified in SOP 1 to SOP 3, such as cost constraints, infrastructure gaps, and technical readiness, by promoting shared resources, cooperative-based financing schemes, and integrated extension services. It draws from the Triple Helix Model (Etzkowitz & Zhou, 2017) and Technology Acceptance Model (TAM), aligning with the findings of Peters et al. (2021), who emphasize that successful agri-tech transfer in the Philippines requires stronger integration of research, extension, and market systems.

IV. CONCLUSION

This study examined the dual dimensions of agricultural technology transfer in Nueva Ecija to identify drivers, barriers, and potential frameworks for sustainable adoption. Findings revealed that farmers generally exhibit high acceptance of agri-tech, particularly in terms of perceived usefulness (M = 4.32), reflecting their recognition of technologies such as mechanical dryers, transplanters, and rice milling equipment in improving yield and efficiency. However, cost implications (M = 3.42) remain a critical barrier, underscoring the need for subsidies, rental schemes, and cooperative financing to enhance affordability.

Institutional roles were found to be effective but uneven, with universities and government agencies leading knowledge dissemination and extension services, while private enterprises excel in commercialization. Yet, gaps in innovation support, coordination, and feedback loops persist, slowing the translation of research outputs into market-ready solutions. Challenges also remain in policy alignment, infrastructure readiness, and farmer capacity, reflecting the systemic issues that constrain the scalability of agri-tech transfer.

These results highlight that successful agricultural technology transfer is not solely a function of innovation availability but of an integrated ecosystem. A collaborative framework anchored in the Triple Helix Model is essential, enabling SUCs like NEUST and CLSU to work synergistically with government agencies, private enterprises, and farmer cooperatives. Strengthening these linkages can accelerate commercialization, expand training and digital literacy programs, and ensure that technologies are both accessible and economically viable for smallholder farmers.

Ultimately, this study calls for holistic, multi-stakeholder strategies that combine research, extension, and market systems to bridge the persistent gaps between institutional innovations and grassroots adoption. By addressing structural challenges particularly cost, infrastructure, and collaborative governance, the Philippines can move closer to achieving a sustainable and inclusive agri-tech ecosystem that empowers farmers and drives national agricultural modernization.

RECOMMENDATIONS

To ensure sustainable and inclusive agricultural technology transfer, this study proposes actionable strategies that integrate policy reforms, collaborative frameworks, and industrial technology-driven solutions. These recommendations are designed to bridge the gap between institutional innovations and farmer-level adoption while aligning with the goals of rural industrialization and technological advancement. A Provincial Agri-Tech Transfer Policy should be developed to formalize collaboration between SUCs (e.g., NEUST and CLSU), DA, LGUs, private enterprises, and cooperatives. This policy must include subsidy programs, equipment rental schemes, and cooperative-based financing models to reduce the financial barriers to adopting advanced agricultural technologies. The Collaborative Framework for Agri-Tech Transfer developed in this study should be adopted as a blueprint for institutional coordination, emphasizing the roles of SUCs in R&D, government in infrastructure and policy, private enterprises in commercialization, and cooperatives in technology adoption and peer learning.

Additionally, a Digital Farmer Support Platform should be developed to integrate training modules, IoT-based equipment scheduling, and real-time market data. Cooperative-managed prototypes of shared-service facilities, such as automated dryers and precision planters, should be piloted to demonstrate the industrial technology applications of agri-tech solutions. Farmer skills must be strengthened through digital literacy programs, technical training, and demonstration farms. The creation of "Farmer Tech Champions" within cooperatives can support continuous peer-to-peer training and proper maintenance of mechanized tools. Furthermore, university-industry-government innovation hubs should be established to accelerate technology licensing, prototype testing, and commercialization. Linking farmers adopting advanced technologies to premium markets will create incentives for sustained adoption. These recommendations underscore the importance of aligning policy, infrastructure, and farmer capacity with industrial technology principles to build a sustainable agri-tech ecosystem. By implementing this roadmap, supported by the proposed Collaborative Framework for Agri-Tech Transfer, Nueva Ecija can become a model for integrating research, extension, and market systems into a holistic industrial technology-driven agricultural sector.

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