upcids Political Economy
UNIVERSITY OF THE PHILIPPINES
CENTER FOR INTEGRATIVE AND DEVELOPMENT STUDIES
ISSN 2619-7278 (Print)
ISSN 2619-7286 (Online)
Policy Brief
2025-39

POLITICAL ECONOMY PROGRAM

MODERN BIOLOGY FOR RURAL DEVELOPMENT

A policy framework for university innovation outputs to sustain higher economic returns for Filipino carabao dairy farmers

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ABSTRACT

Carabao milk has remarkable potential as a raw material for developing high-value dairy products in the Philippines due to its rich nutritional profile and unique physicochemical properties. The Integrative Research Laboratory (IRL Philippines), Institute of Biology, College of Science, University of the Philippines Diliman has developed methods for processing carabao milk using probiotic microorganisms to create NICE4GUT® functional food dairy products. These high-value products not only have a longer shelf life but also offer health benefits to consumers. In partnership with the Center for Integrative and Development Studies – Political Economy Program (CIDS-PEP), we are studying how university-developed technologies like NICE4GUT® Functional carabao cheese can significantly increase the income of small dairy farmers. Toward this end, we propose the following strategies: 1. Enhance government support for dairy farmers' cooperative training and support programs, 2. Implement a Geographical Indication (GI) protection for high-value products produced in specific communities in the Philippines, 3. Promote a community-centered profit-sharing arrangement between Philippine start-up companies or enterprises and farmers' cooperatives.

INTRODUCTION

The development of the Philippine dairy sector is a national priority, with local production of dairy products meeting only a small part of the domestic demand (Turaja et al., 2024; Moijca-Sevilla, 2023; Ang, 2017). The carabao or water buffalo that is usually used as a draft animal can, for instance, be a source for nutrient-rich milk, which may be used in high-value products (the-

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shiv, 2025). The National Dairy Authority (NDA) has set ambitious goals to boost milk self-sufficiency to 5% by 2028, aiming to stop relying on imported cattle by 2035 (DA, 2024). This mission is closely linked to the financial health of smallholder farmers who, as dairy producers, often face challenges like low farmgate prices, market fluctuations, and competition from inexpensive imports (ibid.).

In this connection, foundational laws, such as Republic Act No. 7307 (The Philippine Carabao Act) and Republic Act No. 7884 (The Philippine Dairy Industry Act) that established the Philippine Carabao Center (PCC) and NDA, respectively, have been set up to improve farmer incomes and promote carabao-based businesses (Philippines, 1992; Philippines, Department of Agriculture, 1995). Universities too have begun to contribute to the growth of the sector and farmers' incomes by bringing new technologies to bear on productive activities and processes. However, to our knowledge, there is a significant gap between some of these technologies and their accessibility to farmers in Philippine rural communities.

Therefore, this policy brief aims to complement current efforts and existing laws to strengthen social structures that could support the adoption of university-developed technologies by our dairy farmer cooperatives.

CARABAO FARMERS IN THE PHILIPPINES

In the Philippines, carabao farmers supply the country's carabao milk, producing about 29 million liters in 2023 (PCC, n.d.). Around 99% of these are smallholder farmers who operate with small herds of one to five carabaos, and often rely on manual milking and traditional herd management systems (PSA, 2022; Brown et al., 2025). Furthermore, more than 13,000 active farmers are organized into 227 cooperatives and associations, providing some level of market access, training, and government support (Dagooc, 2023).

Despite their importance, Filipino carabao farmers face a major barrier to improving their earnings: inconsistent raw milk quality (PCC, 2022). Carabao milk is naturally rich in protein and fat, with lower cholesterol and higher calcium than other milk types (Soliman, 2005). However, variations in milk quality, specifically on bacterial count, milk composition, and hygiene practices during production and handling, can reduce its market value (Madududu et al., 2024). These inconsistencies are often linked to limited access to clean water, delayed milk cooling after milking, and structural and logistical constraints (PCC, 2022).

As a result, most farmers earn far below their potential due to limited access to quality resources and market opportunities. According to PCC, on average, carabao dairy farmers earn ₱113,000 annually and are projected to earn up to ₱163,000 in 2025, or roughly ₱9,000 to ₱13,000 per month (Dagooc, 2023). In more favorable situations, especially among well-supported cooperatives or those with government assistance, monthly incomes can reach from ₱12,500 to ₱62,500, particularly when engaging in value-added production like yogurt and milky buns (PNA, 2022).

At present, however, only a small fraction of producers, specifically 59 cooperatives and associations with Food and Drug Administration Licenses to Operate (FDA LTOs), 27 government-assisted farms, and three National Dairy Authority milk collection centers with Licenses to Operate (NDA LTOs) are equipped to process dairy into high-value products (PCC, 2024). The rest are mainly limited to selling raw milk at fluctuating prices, resulting in unstable and often lower incomes.

Expanding processing capacity will require infrastructure and consistent high milk quality. Improving and consistently maintaining high milk quality has the potential to unlock access to premium domestic and export markets that enforce strict quality standards (Madududu et al., 2024). For most farmers, this transition would represent a move away from the income volatility of raw milk sales toward a more stable and profitable position within the value chain. In addition, high-quality milk can serve as the foundation for innovative, market-oriented dairy products with longer shelf lives, stronger brand appeal, and significantly higher market prices (Priyanshantha, 2025). With this, strengthening quality assurance is a pathway to greater profitability and a critical step in enabling more carabao farmers to compete effectively and share equitably in the benefits of the high-value dairy sector.

POLICY LANDSCAPE IN THE PHILIPPINES

In the Philippines, carabao milk cheese production has been recognized in national development frameworks as a strategy to create more value for local dairy, minimize

postharvest spoilage, and improve livelihoods. Several key policies support this direction.

The Philippine Carabao Act of 1992 (Republic Act No. 7307) established the Philippine Carabao Center (PCC) to promote the use of carabaos for meat and milk, including the processing and commercialization of carabao milk products like cheese. The PCC has since established a Central Processing Plant at its national headquarters, producing mozzarella, caciocavallo, and probiotic cheeses from buffalo milk. Staff were trained in Korea to ensure global competitiveness (Antaran, n.d.).

The Philippine Dairy Industry Act of 1995 (Republic Act No. 7884) created the National Dairy Authority (NDA) under the Department of Agriculture (DA) to oversee the development of the dairy sector. The NDA is mandated to design and implement dairy programs that significantly impact nutrition and income levels in both rural and urban areas (Philippines, Department of Agriculture, 1995).

Financial support is also a key factor. In 2025, the Agricultural Credit Policy Council (ACPC) and PCC launched a dedicated credit window under the Agri-Negosyo (ANYO) Loan Program. This program offers accessible financing of up to ₱300,000 for individual farmers and up to ₱15 million for micro and small enterprises or cooperatives. A low annual interest rate of 2% and a 3.5% service fee for individuals lowers the financial barrier for those looking to invest in cheese production facilities and equipment (ACPC, 2025).

Another significant policy is the Masustansyang Pagkain para sa Batang Pilipino Act (Republic Act No. 11037), which institutionalized the National Milk Feeding Program. For this initiative, the PCC partners with the Department of Education (DepEd), the Department of Social Welfare and Development (DSWD), and local cooperatives to supply processed dairy products, including pasteurized carabao milk, to undernourished children in schools and daycare centers. Since 2019, 43 DA-PCC cooperatives have supplied over 116 million milk packs to nearly 4 million children, generating more than ₱2.06 billion in gross income for farmer cooperatives (Tecson, 2023). This program provides direct nutritional support while creating a reliable market, encouraging farmers to diversify their operations and invest in processing capabilities.

Furthermore, the Philippine Innovation Act (Republic Act No. 11293) encourages the commercialization of research from academic institutions, such as the University of the Philippines. This law encourages technology transfer and industry collaboration, which is essential for transforming scientific research into profitable cheese production ventures (DEPDev, 2020).

FROM MILK TO HIGH-VALUE CHEESE

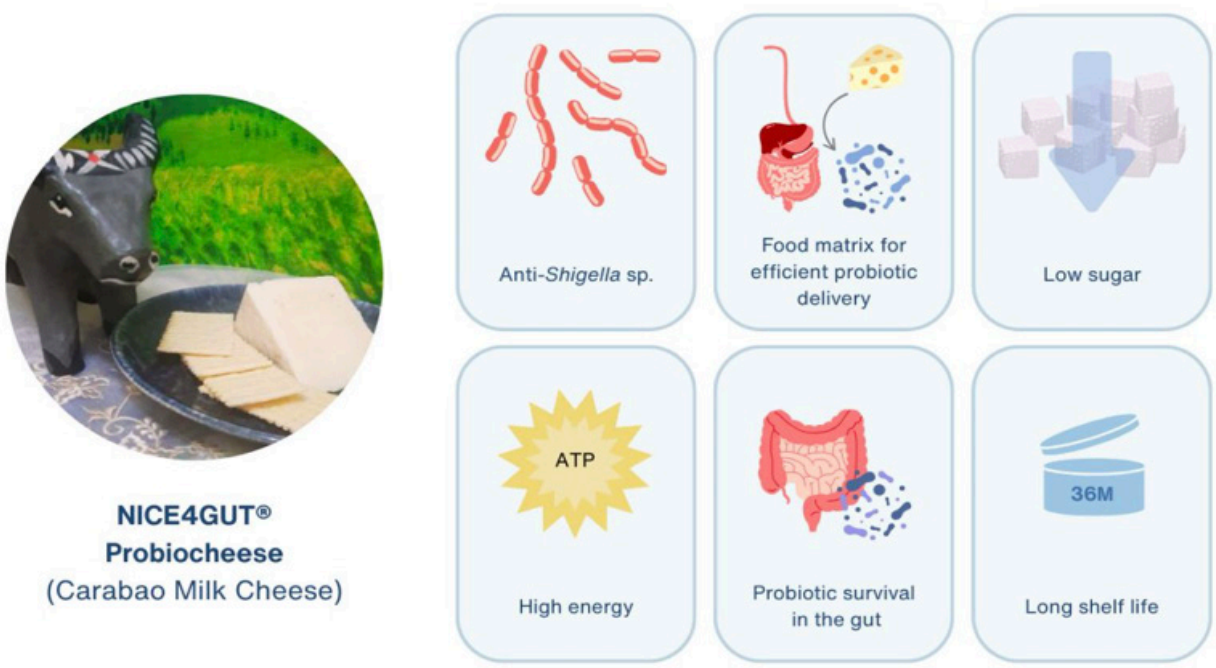
Building on this policy landscape, producing high-value dairy products like cheese offers a powerful solution to the challenges faced by smallholder farmers, such as low farmgate prices and the short shelf life of raw milk (PCC, 2022). In an import-dependent market, where the locally produced milk cannot meet the national demand, value-added products can provide a strategic pathway to increase economic returns (PCC, 2022).

The Philippine dairy market is expanding, driven by a growing population and increasing income of consumers (the-shiv, 2025). In particular, the growth is strong in the value-added and fortified dairy products market is strong, as health-conscious consumers seek healthier food options (Del Castillo & Ward, 2025). NICE4GUT® Functional Carabao Cheese, a semi-hard aged cheese, is positioned to capture this demand. As consumers become more health-conscious, they are willing to pay for premium foods marketed for their health benefits (Alsubhi et al., 2022).

Along this line, the NICE4GUT® Functional Carabao Cheese, a product of IRL Philippines, Institute of Biology, College of Science, University of the Philippines, Diliman represents a significant step towards developing high-value carabao milk products. The invention is a semi-hard aged cheese made from buffalo's milk using a starter culture comprising lactic acid bacteria, with anti-*Salmonella*, anti-*Shigella*, anti-inflammatory, and other beneficial health properties. Notably, live probiotic microorganisms can be recovered from the product after three months of aging, and the product is free of microorganisms that lead to spoilage, even after more than three years of storage, at which point beneficial compounds that promote health are captured by the cheese matrix.

The NICE4GUT® functional carabao cheese is a unique 3-in-1 functional food product specifically developed for children and the elderly (Figure 1). It is designed to:

1. provide high energy and protein to meet daily nutritional requirements;
2. provide health benefits; and
3. increase compliance in completing therapeutic regimens.



■ **Figure 1. Competitive Advantages and Functional Benefits of NICE4GUT® Probiocheese.** This figure illustrates the key attributes of NICE4GUT® Probiocheese, including its ability to exhibit anti-*Shigella* activity, serve as an efficient food matrix for probiotic and beneficial compound delivery, offer low sugar with high energy, and provide a long shelf-life. These features underscore its value proposition for consumers and its potential to enhance economic returns for carabao dairy farmers.

A key advantage of processing carabao milk into cheese is the significant increase in its value and demand. The Philippine cheese market reached US$356.45 million in 2025 and is projected to grow by 9.77% annually (Statista, n.d.), offering strong economic potential. Based on the initial estimates of IRL Philippines, we envision a scenario where 100 liters of carabao milk sourced from about 25 heads can yield 10 cheese wheels, each averaging 1.8 kg. Entering into this enterprise will add a profit ranging from ₱116 to ₱1,289 (50-200% markup) on top of the purchase value of milk, which is ₱150, resulting in a significant increase in the value of milk, demonstrating the potential for substantial economic gains. Beyond the primary product, IRL Philippines promotes sustainability by valorizing cheesemaking waste by-products, such as liquid whey, into other functional food products, reducing waste, and supporting eco-friendly practices while adding another layer of profit.

In summary, NICE4GUT® carabao cheese and whey functional food production aims to not only enhance farmer livelihoods but also contribute to public health and environmental sustainability.

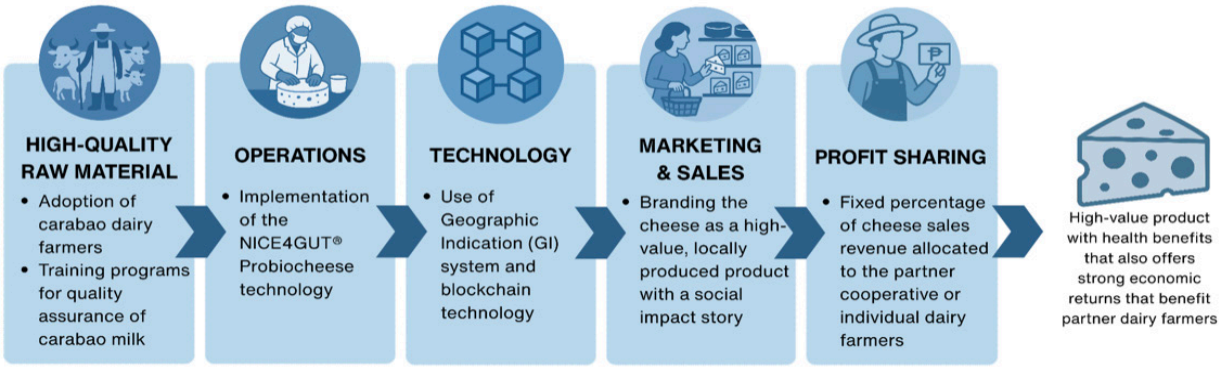
NICE4GUT® FUNCTIONAL CARABAO CHEESE PRODUCTION MODEL TO UPLIFT THE LIVES OF FARMERS

To uplift the lives of farmers utilizing a university-developed technology, we propose a community-based approach to producing NICE4GUT® functional carabao cheese. Here, a community of smallholder farmers are organized into a cooperative, each farmer contributes milk from their herd, and, the group is responsible for maintaining high-quality standards. Upskilled cooperative members, along with cheesemaking facilities, produce probiotic cheese, turning raw milk

into a high-value product with a long shelf life. The production of the NICE4GUT cheese proceeds in four interconnected stages, as visualized in the value chain framework (Figure 2), which would transform raw carabao milk into a profitable and sustainable product.

Cooperatives who will adopt the NICE4GUT® Functional carabao cheese technology will require various support. In order to meet quality standards for high-quality milk and other high-quality products, carabao dairy farmers who will adopt will need to undergo government training programs such as ones being conducted by the Dairy Training and Research Institute (DTRI). University-led start-ups or spin-offs may also partner with the farmer community as envisioned by Republic Act No. 11293 or the Philippine Innovation Act and RA 10055 or the Technology Transfer Act to bring outputs of research to market and marginalized communities. The locally-produced functional food backed by scientific data and with a strong social impact story may then be sold as a premium.

High-value products produced through this approach may be protected under the Geographic Indication (GI) system and improved by blockchain technology for traceability and quality assurance. The Food Authenticity and Traceability Program developed by the Philippine Nuclear Institute (PNRI) and the De La Salle University (PNRI 2023), serves as a good model for this strategy. Finally, to ensure that the community prospers as the product becomes more profitable, a fixed percentage of the sales revenue (profit-sharing) will be shared with the farmers and cooperatives, linking their income to the product's success, encouraging consistent quality and production improvements.



■ **Figure 2. Value Chain Framework for NICE4GUT® Functional Carabao Cheese Production and Distribution.** This figure presents the key activities involved in making NICE4GUT® Functional Carabao Cheese a high-value product. The process begins with the adoption of a community of carabao dairy farmers who will undergo training programs to ensure the consistent production of high-quality raw milk. It continues with the partnership with a company that will implement the technology, which utilizes a starter culture with anti-*Shigella*, anti-*Salmonella*, and anti-inflammatory properties. The cheese will be integrated into a GI system and supported by blockchain technology to ensure full traceability and assure consumers that it is sourced exclusively from partner dairy farmers. The cheese is then introduced in the market as a premium, locally produced product. Finally, the value chain ensures sustained financial support for partner dairy farmers through a fixed percentage profit-sharing arrangement.

POLICY RECOMMENDATIONS

The following policy recommendations aim to establish a foundation for university innovation outputs and farmer community enterprises to flourish and make a concrete societal impact on rural development.

1. **Enhance government support for dairy farmers' cooperative training and support programs.**

   Consistent raw milk production that meets quality assurance standards is essential for profitable high-value dairy enterprises. Therefore, smallholder carabao farmers need to be skilled in hygienic milking techniques, proper milk handling and storage, animal health and nutrition management, and equipment sanitation to minimize bacterial contamination and preserve the composition of carabao milk. The Philippine Carabao Center and the National Dairy Authority support these initiatives.

   We propose to enhance the competencies of dairy farmers through government-funded dairy training

programs and incentives for farmer cooperatives that adopt new Philippine-made technologies. This will help prevent waste and ensure the quality and safety of the raw milk supply.

Additionally, we recommend the establishment of a "Microbiologists for the Barrios" Fellowship program. Under this program, the Department of Agriculture (DA) or the Department of Trade and Industry (DTI) could hire Microbiologists in various regions to improve quality assurance testing of milk within farmer cooperatives' processing facilities. This initiative could be integrated into the Department of Science and Technology's (DOST) scholarship program, providing young Filipino scholars passionate about serving rural communities with an option for returning service to the country.

2. **Implement a Geographical Indication (GI) protection for high-value products produced in specific communities in the Philippines.**

Branding high-value products, such as carabao cheese—a functional food produced under strict quality standards by trained farmers—can help protect the local identity, enhance product value, and ensure traceability.

We propose using Geographical Indication (GI) as a method to connect this Filipino-made product to the community where it is produced and processed. Through the Intellectual Property Code (RA 8293) and the support of the Intellectual Property Office of the Philippines (IPOPHL), GI protection, paired with the integration of blockchain technology for transparent and traceable labels, will help maintain product integrity and brand value. This approach will promote community development and increase the product's potential for global appeal and competitiveness.

3. **Promote a community-centered profit-sharing arrangement between Philippine start-up companies or enterprises and farmers' cooperatives.**

Our society should benefit significantly from research and technologies developed by public universities and funded by the government. Therefore, innovations like NICE4GUT® Functional carabao cheese must be utilized in a way that uplifts the lives of Filipino farmers.

We propose a policy that integrates farmers as key partners with companies that adopt government-funded research and technology. This partnership would involve using farmers' raw agricultural products either as contributions to gain shares in start-up companies or to gain a share in product unit sales. This approach allows Filipino farmers to benefit directly from the technology alongside their partner companies.

The proposed policy will enhance the social impact of the Philippine Innovation Act (RA 11293) and the Technology Transfer Act (RA 10055). By implementing this policy, farmers will have a stake in ensuring a steady supply of high-quality raw materials necessary for sustaining the enterprise.

Importantly, as these technology-adoptor enterprises grow, farmers will not simply remain as raw material suppliers. By linking farmer income directly to a percentage of product sales through profit sharing, this model enables farmers to earn higher incomes and ensures that they grow alongside their partner deep-tech companies.

CONCLUSION

Academic research institutions are fertile ground for scientific discoveries, innovations, and inventions. The Philippines produces highly skilled young scientists who are sought after globally for their talent, creativity, and innovative thinking. The country is abundant in human, natural, and technological resources, yet most of these assets have not been effectively transformed into tangible contributions to our national economic development.

This policy brief outlines one university-developed technology that may contribute to improving farmers' incomes and lives. The policy recommendations aim to help farmers gain access to advanced technologies and high-end markets. The objective is to increase the income that Filipino farmers earn from their agricultural products and elevate them from mere suppliers of raw materials to valued partners of local deep-tech enterprises.

Implementing Geographical Indication (GI) and blockchain technology will safeguard and brand products produced by specific communities. The establishment of a community brand will foster a culture of care and initiative, or '*malasakit at pakukusa*,' while ensuring that community members remain vigilant in consistently producing high-quality products. Most importantly,

this approach will guarantee that the success of local enterprises contributes to community development.

The proposed multi-dimensional approach that links technology and stakeholders, on the one hand, and this to policy, on the other hand, is designed to encourage a new generation of scientist-entrepreneurs who are vested in seeing their innovations make a positive impact on people's lives.

AUTHORS CONTRIBUTIONS

JAUA helped draft the manuscript, conceptualized the adoption of the NICE4GUT Functional Carabao Cheese technology in addressing the problems faced by Filipino carabao dairy farmers and researched on relevant Philippine laws, PCDCI contributed to writing the introduction and technology production model sections, participated in the ideation and drafting of the policy recommendations, and researched on the positioning of high-value products in the market, JJR researched on current situations of Filipino carabao farmers including practices, income, and challenges, examined implications of milk quality and potential of consistent high-quality milk, and participated in the ideation and drafting of the policy recommendations, MMT transcribed statements about features of NICE4GUT Functional Carabao Cheese, helped with the cost analysis of the product, and contributed on the ideation and drafting the From Milk to High-value Cheese Section. ARR helped conceptualize farmers' participation in technology adoption and helped edit the manuscript. JAI conceptualized the research, policy framework, and community branding and profit-sharing strategy for rural development, conceptualized and wrote the policy recommendations and conclusions, and edited the manuscript.

ACKNOWLEDGEMENTS

Nina Claire R. Bahin illustrated the value chain and policy framework. Canva was used to create the figures in this policy brief. Grammarly was used for copyediting the manuscript. Andelyn Cañas provided valuable comments on the initial draft of the manuscript. Honey B. Tabiola copyedited the initial draft of the manuscript. NICE4GUT Functional Carabao Cheese and whey production methods were first developed in 2018 to 2020 by Janina M. Guarte and Ingrid Puentespina as part of their thesis research with support from the Young Innovators' Program (YIP) of the Philippine Council for Industry, Energy, and Emerging Research and Development (DOST-PCIEERD). Ms. Ingrid Puentespina helped in costing analyses. The DOST-PCIEERD-CRADLE program awarded to JAI, funded the production of the technology in partnership with Malagos Food, Inc. JAUA was employed by the UP System Technology Transfer and Business Development Office under the supervision and mentorship of JAI. JAI is supported by the UP TTBDO and the DOST-Philippine Council for Health Research (PCHRD) This policy paper is supported by the Center of Integrative and Development Studies-Political and Economy Program (CIDS-PEP).

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