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Investing in climate-smart dairy value chains in Egypt

Risks and opportunities for private sector engagement

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Abbreviations

AfDB	African Development Bank
AMCS	Automated Milk Collection System
BMUV	German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection
CAPEX	Capital Expenditure
CAPMAS	Central Agency for Public Mobilization and Statistics
CERC	Carbon Emission Reduction Certificate
CFI	Chamber of Food Industries
CIF	Climate Investment Funds
CMC	Compressed Methane Certificate
DFI	Development Finance Institution
DIDA	Dairy Industry Development Association
EGX	Egyptian Stock Exchange
EMPA	Egyptian Milk Producers Association
ETS	Emissions Trading System
FAO	Food and Agriculture Organization of the United Nations
FLC	First Loss Capital
FTRI	Food Technology Research Institute
FX	Foreign Exchange
GCF	Green Climate Fund
GHG	greenhouse gas
IKI	International Climate Initiative
ILO	International Labour Organization
IRR	Internal Rate of Return.
MCC	Milk Collection Center
MSMEs	Micro, Small, and Medium Enterprises
NAP	National Adaptation Plan
NDC	Nationally Determined Contributions
NPV	Net Present Value
OECD	Organization for Economic Co-operation and Development
OPEX	Operational Expenditure
SCALA	Scaling up Climate Ambition on Land Use and Agriculture
SHARP+	Self-evaluation and Holistic Assessment of climate Resilience of farmers and Pastoralists
TTE	Think Tank Egypt
UHT	Ultra-High Temperature
WB	World Bank

Units of measurement

kg	Kilogram
ton	Metric ton
L	Liter
m^3	Cubic meter
°C	Degree Celsius
CO_2e	Carbon dioxide equivalent
m^2	Square meter
kg/head/year	Kilograms per animal per year
kg/day	Kilograms per day
MWh	Megawatt-hour
kg CO_2-eq / 1 L product	Kilograms of CO_2 equivalent per liter of product
m^2 / 1 L product	Square meters per liter of product
L / 1 L product	Liters of water per liter of product

Currencies

USD	United States Dollar
EGP	Egyptian Pound

Chemical formulae

CO_2	Carbon dioxide
CH_2	Methane
N_2O	Nitrous oxide

Executive summary

Egypt's agricultural sector is a vital part of its economy, contributing to 11 percent of its GDP – a value of USD 37.4 billion in 2022. Within this sector, animal production accounts for USD 13.7 billion, with milk production playing a particularly important role. Egypt’s dairy sector is a fundamental pillar of the country’s agricultural economy, contributing approximately 37.5 percent of total agricultural production and generating an estimated USD 8 billion annually. The industry supports the livelihoods of more than 1.8 million households, many of which are small-scale farming households. Despite its economic significance, the sector faces mounting challenges due to climate change, which threatens milk production, livestock health, and overall sustainability. Rising temperatures, increasing water scarcity, feed shortages, and fluctuating production costs are placing immense pressure on dairy farmers, particularly small- and medium-scale producers.

As a result, Egypt’s Nationally Determined Contribution (NDC), as part of its climate action planning, explicitly targets the agriculture, forestry, and other land-use (AFOLU) sector—including the dairy subsector—by mandating measures such as the recycling of agricultural waste and manure as part of mitigation efforts. Egypt’s National Climate Change Strategy (NCCS 2050), adopted in 2022, expands its adaptation and mitigation framework across all major sectors—including agriculture and livestock—and explicitly prioritizes building sectoral resilience and strengthening governance and climate financing systems. The strategy emphasizes enhancing the adaptive capacity of the livestock sector—particularly dairy—by integrating climate-resilient animal production practices, early-warning systems, and improvements in water and feed management—measures that align directly with dairy resilience goals. In addition, Egypt’s GCF-backed Climate Investment Plan explicitly mentions private investment into low-carbon, climate-resilient dairy production systems, aiming to enhance productivity and sustainability in the dairy subsector.

This study, conducted within the framework of the Scaling up Climate Ambition on Land Use and Agriculture (SCALA) programme, assesses opportunities for private sector engagement in climate-smart dairy production and investment. By mapping the dairy value chain and analyzing climate risks, the study identifies practical interventions that can enhance sustainability and resilience across Egypt’s dairy industry.

Geographical differences are a significant hallmark of Egypt's dairy sector, with the delta region dominating dairy production, accounting for 55.6 percent of total milk output. The delta benefits from larger herd sizes and better access to veterinary services, feed, and markets, leading to higher milk yields and a more structured value chain. In contrast, Upper Egypt accounts for 44.4 percent of total milk production, and is characterized by smaller herd sizes, lower productivity due to limited access to resources, and a reliance on informal markets.

The dairy value chain in Egypt consists of several interdependent nodes, each involving different actors with distinct roles. Milk production occurs across three main systems: intensive, semi-intensive, and extensive. Intensive dairy farming, which incorporates 6 percent of livestock, uses high-tech equipment and imported breeds, achieving milk yields of 32-35 kg/day per cow, but faces the challenges of high water demand and heat stress. Semi-intensive farming, accounting for 35 percent of livestock, involves medium-sized farms with mixed breeds and partial mechanization, yielding 10-20 kg/day. Extensive farming, the most common, with 59 percent of livestock, consists of small farms with minimal inputs, resulting in milk yields of 5-9 kg/day. These systems influence productivity, market access, and climate resilience, with large farms supplying formal processors, medium farms selling to milk collection centers, and smallholders selling directly to local consumers or through middlemen.

Climate change has already begun to significantly impact Egypt's dairy sub-sector, with heat stress emerging as a major concern, particularly for large-scale farms that rely on high-yield breeds such as Holstein cows. These cows experience a 10–25 percent decline in milk yield due to prolonged exposure to high temperatures, along with reductions in fertility rates and increased mortality. In Kafr El-Sheikh governorate, hot summer months have led to a 39 percent reduction in total milk yield for Friesian cows, with milk fat content dropping by 7.92 percent and protein content by 4.06 percent. Additionally, feed and water scarcity pose ongoing challenges, as Egypt produces only 35 percent of its required animal feed, instead relying on annual imports of 9 million tonnes of maize and 3 million tonnes of cereals. This heavy dependence on imported feed makes the sector vulnerable to global price fluctuations and currency exchange risks.

Market and supply chain vulnerabilities also pose significant risks. Egypt produces 6.13 million tonnes of milk annually, but losses account for nearly 15 percent of total production due to inadequate cooling and transportation infrastructure. The sector remains highly fragmented, with 75 percent of total milk production coming from subsistence-level and traditional farming systems. Only 10 percent of Egypt's fresh milk is processed through modern dairy enterprises, while the rest is sold through informal markets, leading to inconsistencies in quality, pricing, and safety standards. Furthermore, the dairy industry is a notable contributor to greenhouse gas (GHG) emissions, particularly methane, which accounts for 51–67 percent of total dairy emissions. Without intervention, climate-related disruptions could reduce per-capita milk availability, which currently stands at 75 liters per year, further increasing Egypt's reliance on dairy imports.

Despite the urgent need for climate adaptation, several barriers hinder private sector investment in climate smart solutions for sustainable dairy production. The high capital costs associated with climate-smart technologies, such as solar-powered cooling systems and biogas digesters, make it difficult for small–and–medium–scale farmers to adopt these solutions. Many of these farmers struggle to access financing, as commercial banks impose high interest rates and require extensive collateral, limiting the availability of long-term credit. Additionally, a lack of awareness and technical expertise prevents many dairy farmers from implementing climate-smart practices.

Training and capacity-building programmes are essential to ensuring the successful adoption of technologies such as solar energy integration, efficient feed management, and manure-based biogas production. Regulatory challenges also persist, with weak enforcement of quality standards, fragmented supply chains, and insufficient incentives for sustainable practices discouraging private sector engagement. The absence of carbon pricing mechanisms in Egypt further reduces the financial attractiveness of emissions-reduction projects, slowing down the transition to more sustainable dairy farming methods.

One of the most promising areas is the adoption of solar energy in dairy farms. Large-scale farms that have already integrated solar-powered systems for electricity generation, water heating, and milk cooling have managed to reduce their operational costs by 30–40 percent, while significantly cutting carbon emissions. Expanding solar-powered mobile cooling units can help smaller dairy farms reduce milk spoilage, improve quality, and enhance market access. Studies from Tunisia and Kenya demonstrate that solar-powered milk cooling has reduced transportation-related losses by 20 percent, offering a scalable solution for Egypt's dairy sector.

Another critical investment opportunity lies in efficient feed management, including the expansion of silage and dry feed production to reduce reliance on expensive imports. Addressing Egypt's 7.34 million-ton feed deficit through local feed production can significantly enhance the economic viability of dairy farming. Additionally, utilizing agricultural waste as an alternative feed source could offset over 15 percent of feed costs, improving profitability for small- and medium-scale farms. Advances in feed formulation technologies can further optimize livestock nutrition, increasing milk yield while reducing methane emissions per unit of milk produced.

Biogas production from manure presents another transformative opportunity for Egypt's dairy sector. Each cow produces 15–35 kg of manure per day, which, when processed through anaerobic digestion, can generate 44,000 MMBTU of biogas annually for a 3,000-cow farm. This renewable energy source can replace fossil fuels, reducing methane emissions by 20–80 percent while providing farms with organic fertilizers valued at EGP 350 per ton. Carbon credit trading for methane reduction could create an additional revenue stream for farmers, with biogas projects offering payback periods of 6–8 years, particularly when supported by financial incentives.

The growing market for plant-based dairy alternatives also presents a profitable opportunity. Egypt's plant-based milk market, currently valued at USD 22 million, is projected to grow at an annual rate of 16.87 percent, reaching USD 47.98 million by 2029. Establishing a soy-based dairy facility in Egypt can significantly reduce GHG emissions by 78 percent, land use by over 90 percent, and water consumption by more than 95 percent compared to traditional dairy. The project shows strong financial viability; however, market penetration and consumer acceptance remain key challenges. De-risking measures, such as government incentives, blended finance, and strategic partnerships, are essential to mitigate risks. Additionally, contract farming, regulatory engagement, and consumer awareness campaigns will support long-term success, ensuring economic growth, food security, and reduced import dependency.

To unlock these investment opportunities, the study recommends several de-risking mechanisms to encourage private sector participation. Establishing blended finance mechanisms, such as low-interest loans, first-loss capital, and risk-sharing instruments, could provide the necessary financial support for climate-smart investments. Additionally, integrating dairy farms into carbon credit trading schemes could create new revenue streams by monetizing emissions reductions from sustainable practices such as biogas production and improved feed efficiency.

Strengthening public-private partnerships (PPPs) will be essential to accelerating the adoption of climate-smart solutions, fostering collaboration between government agencies, financial institutions, dairy processors, and technology providers. Expanding capacity-building programmes will also be crucial in equipping dairy farmers with the technical knowledge and skills needed to implement sustainable practices effectively. Furthermore, regulatory reforms—such as streamlined permitting processes for renewable energy projects, incentives for feed-efficient dairy farming, and stricter methane reduction policies—will further support the transition to a more sustainable dairy industry.

This study concluded that, while climate change presents significant risks to the dairy subsector in Egypt, it also offers opportunities for transformational investments that can enhance sustainability, resilience, and profitability. By mobilizing private sector engagement, promoting innovation, and implementing targeted financial and policy interventions, Egypt can build a climate-smart dairy value chain that secures long-term food security, economic growth, and environmental sustainability. This report provides a comprehensive roadmap for key stakeholders—including government agencies, financial institutions, dairy producers, and investors—to collaborate in driving climate-smart dairy transformation in Egypt. By taking immediate action, Egypt can create a more resilient, efficient, and profitable dairy sector that benefits millions of farmers and consumers alike.

Key messages and recommendations for private sector engagement.

Egypt's dairy sector is at a critical juncture, presenting real opportunities for private sector investment and innovation, particularly in climate-smart solutions. The increasing demand for dairy products, coupled with the urgent need to address climate change impacts, creates a compelling business case for transformative engagement. The following strategic recommendations are designed for private sector actors looking to capitalize on these opportunities and contribute to a resilient and sustainable dairy value chain in Egypt.

1. Invest Strategically in High-Impact, Climate-Smart Technologies

The Egyptian dairy sector, valued at USD 8 billion annually, offers significant market potential where climate-resilient practices can drive profitability. By investing in proven technologies, companies can mitigate risks like heat stress and resource scarcity while reducing costs and creating new revenue streams.

- **Solar Energy:** Invest in solar photovoltaic (PV) systems for on-farm electricity, solar-powered water heating, and milk chilling units to lower operational costs, enhance energy security, and reduce carbon emissions.
- **Efficient Feed Management:** Invest in the local production of silage and advanced feed formulations, and utilize agricultural waste. This lowers reliance on imports, decreases costs, and reduces methane emissions per unit of milk.
- **Manure Management and Biogas:** Implement anaerobic digestion systems to convert manure into biogas for renewable energy and organic fertilizer. This creates value from waste, reduces GHG emissions, and opens potential access to carbon credits.
- **Plant-Based Dairy Alternatives:** Capitalize on the growing market for plant-based milk by investing in local production facilities for products like soy milk, which have a lower environmental footprint and meet evolving consumer demands.

2. Leverage Innovative Financing and De-Risking Mechanisms

While initial investments in climate-smart technologies can be substantial, strategic financial planning can make these projects highly attractive. Economic viability is achievable through measures that improve financial returns and shorten payback periods.

- **Innovative Financing:** Actively engage with financial institutions, climate funds (e.g., GCF), and Development Finance Institutions (DFIs) to access blended finance, low-interest loans, and risk-sharing instruments.
- **Carbon Markets and Renewable Energy Certificates:** Explore opportunities to monetize emissions reductions through voluntary carbon markets and generate revenue from International Renewable Energy Certificates (I-RECs) for solar projects.
- **Insurance Products:** Advocate for and utilize comprehensive insurance options that cover a wider range of climate-related production risks beyond just livestock mortality.

3. Foster Strategic Partnerships

Collaboration is crucial for success. Public-private partnerships and industry-wide cooperation are essential to overcome barriers, share knowledge, and effectively scale up climate-smart solutions.

- **Public-Private Partnerships (PPPs):** Engage in PPPs to facilitate technology transfer, infrastructure development, and policy advocacy for a more supportive business environment.
- **Industry Collaboration:** Work with industry associations (like EMPA) and research institutions (like FTRI) to share best practices, develop industry standards, and collectively address common challenges.
- **Supply Chain Integration:** Develop stronger relationships with small and medium-scale producers through mechanisms like contract farming to ensure stable and resilient supply chains.

4. Advocate for a Supportive Policy and Regulatory Environment

A clear and encouraging policy framework is fundamental to unlocking investment and ensuring long-term success.

- **Engage with Policymakers:** Advocate for streamlined permitting for renewable energy projects, stable net metering policies, and clear, supportive regulations for emerging markets like biogas and carbon credits.
- **Support Quality Standards:** Promote the development and enforcement of quality standards and certifications to enhance market confidence and drive demand for sustainable products.

5. Enhance Operational Efficiency and Build Capacity

Adopting sustainable practices enhances competitiveness by meeting the growing consumer demand for responsibly produced goods, which can improve brand reputation and open niche markets.

- **Invest in Technical Expertise:** Implement training programmes for staff and farmers to build the technical capacity needed to manage climate-smart technologies effectively.
- **Enhance Water Management:** Implement water-efficient irrigation and water recycling systems to combat scarcity.
- **Adopt Data-Driven Management:** Use modern farm management practices, including detailed record-keeping and data analysis, to optimize resource use and improve decision-making.
- **Promote Consumer Awareness:** For new sustainable products, invest in marketing and consumer education campaigns to highlight their benefits and drive market adoption.

Chapter 1. Objectives, approach and methodology

1.1. Objectives

Overall Objective

The primary objective of this study under SCALA is to assess opportunities for private sector engagement and identify investments in transformative climate action within Egypt's dairy production sector. The SCALA programme, funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), is a multi-year initiative implemented by FAO and UNDP. It supports 12 partner countries across Africa, Asia, and Latin America to drive transformative climate action in land use and agriculture, aiming to reduce greenhouse gas emissions, enhance removals, and strengthen resilience to climate change. The programme focuses on translating NDCs and NAPs into actionable climate solutions with multistakeholder engagement, emphasizing public and private sector collaboration.

The specific objectives of the study

- **Mapping the dairy subsector:** This objective focuses on conducting a thorough analysis of the Egyptian dairy subsector. This includes identifying and mapping key private sector actors across the entire value chain, from producers to consumers. The analysis will evaluate the sector's size, productivity levels, and working conditions. Additionally, it will assess the social and economic factors influencing the sector's overall environment.
- **Analyzing value chains and climate risks:** This objective aims to identify opportunities and constraints within the dairy value chains, prioritizing those with significant potential for sustainable growth. A comprehensive assessment of climate risks and their impact on businesses will be conducted. This includes exploring adaptation and mitigation solutions, identifying barriers to adopting climate-smart practices, uncovering business opportunities, and developing de-risking strategies. Finally, this objective will highlight feasible entry points for interventions that address bottlenecks and unlock the subsector's full potential for all stakeholders.
- **Facilitating multi-stakeholder engagement and investment:** This objective focuses on fostering collaboration and mobilizing investment for climate action within the dairy sector. It involves mapping the private sector landscape to identify potential partners aligned with national climate priorities, as outlined in the Nationally Determined Contributions (NDC) and National Adaptation Plans (NAP). This objective will facilitate multi-stakeholder collaboration between the public and private sectors and strengthen the evidence base for private sector engagement in climate action. Furthermore, it will address barriers to private investment by suggesting both public and private de-risking instruments and promoting alternative solutions.

1.2. Approach and methodology

Approach

This study adopted a mixed-methods approach to comprehensively investigate the multifaceted climate-related challenges, opportunities, and investment needs within Egypt's livestock and dairy sector, placing significant emphasis on the role and potential of the private sector. The rationale behind choosing a mixed-methods approach was to leverage the strengths of both qualitative and quantitative data, providing a holistic understanding of the complex interplay of factors influencing the sector. Primary research was designed to gather direct, firsthand experiences from private sector actors, offering valuable insight into their operational realities, perceived risks, and potential contributions to climate resilience. Complementing this, secondary data analysis, through a review of existing literature, reports, studies, government records, and industry data, provided a broader contextual understanding of key elements, existing value chains, market trends, policy frameworks, and potential opportunities for private sector investment and innovation in climate change mitigation and adaptation.

Methodology

The primary data collection phase employed a combination of qualitative methods, specifically Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs), to delve deep into the nuances of private sector perspectives within the dairy industry. A structured questionnaire (provided in Annex 3) was developed to ensure comparability across interviews and discussions, guiding the exploration of challenges, opportunities, and climate-related risks faced by businesses. A strategically selected sample of 72 stakeholders, representing the diverse spectrum of private sector actors within the dairy value chain (detailed in Annexes 1 and 2), participated in the study. This sample included livestock and milk producers across different scales of operation (smallholders, medium-sized farms, and large-scale producers), input suppliers (feed providers, etc.), dairy processors of varying sizes and market positions, and financial institutions providing services to the sector. Key private sector players in dairy production, such as Juhayna, Almarai Egypt (and its subsidiary Beyti), Danone Egypt, Domty, Dina Farms, and Lammar, were specifically targeted due to their significant influence in the sector. Furthermore, representatives from relevant industry bodies and supporting organizations, including the Chamber of Food Industries, the Agricultural Bank of Egypt, the National Bank of Egypt, and e-Finance for Digital and Financial Investments, were included to provide a broader industry perspective. Engazaat, specializing in sustainable business solutions, contributed insights into the intersection of private sector activity and environmental sustainability. Finally, to incorporate a governmental perspective and understand the policy context shaping private sector engagement, representatives from the Ministry of Agriculture and Land Reclamation's Animal Production Sector were also surveyed.

Field visits were undertaken in six governorates, strategically chosen to represent both the Delta region (Behera, Monofya, and Sharqia) and Upper Egypt (Menya, Beni Suef, and Suhag). These governorates collectively account for approximately 50 percent of Egypt's national livestock population, according to data from the Central Agency for Public Mobilization and Statistics (CAPMAS, 2021). The field visits involved a combination of one-on-one meetings (KIIs) and FGDs, tailored to the specific scale of operation and local context of the participants, ensuring engagement with both large-scale producers and small-scale operators.

Chapter 2. An overview of livestock production, challenges and rural livelihoods

2.1. Economic significance and social impact

The livestock subsector is a cornerstone of Egypt's agricultural economy, representing 37.5 percent of the total value of agricultural production, even though agriculture contributes 11 percent to the nation's GDP (Statista, 2023). Cattle and buffaloes, the primary livestock animals, produce approximately 6 million tonnes of milk and 500 000 tonnes of meat annually. Cattle contribute to 53 percent of total milk production and 86 percent of meat production, with buffaloes making up the rest. The combined annual output of cattle and buffaloes is valued at an estimated USD 8 billion. Despite this substantial production, Egypt remains a net importer of both beef and milk. On a per capita basis, annual consumption stands at 9 kg of beef and 75 liters of cow milk per person (FAO, 2020).

A significant portion of the population, over 1.8 million households, raise livestock, primarily for commercial ventures. These animals serve as a valuable asset, providing a consistent income stream through milk sales and offering valuable inputs that enhance crop productivity in integrated crop-livestock farming systems (FAO, 2020). However, livestock production is largely concentrated in irrigated cropping regions due to the scarcity of natural forage resources in Egypt's desert areas, which can only support limited numbers of camels, sheep, and goats. This concentration creates both synergies and competition between livestock and crop production. During the winter, nearly half of Egypt's arable land is dedicated to cultivating berseem (Egyptian clover) for livestock feed, potentially diverting land from other food crops like wheat or beans. (Ayyad *et al*., 2024). Conversely, the summer months see a marked deficit in forage and roughage, creating challenges for livestock feeding.

Livestock ownership is a critical safety net, particularly during crises, strengthening farm resilience and contributing significantly to daily household sustenance (FAO, 2016). In Egyptian farming systems, characterized by small landholdings, integrating livestock provides a crucial alternative livelihood pathway. This integration offers a means of building resilience, especially against the impacts of climate change and extreme weather, by supplementing income for small-scale farmers and reducing reliance on a single crop. The diversification afforded by livestock helps to buffer against both climatic variability and market price volatility. Income generated from livestock sales can provide crucial support during periods of crop failure or diminished yields. A study by Saad (2024) across various Egyptian regions underscores livestock's role as a pillar of rural economic stability, offering crucial avenues for poverty reduction and economic resilience within agricultural communities. This sub-sector acts as an essential safety net, particularly for landless farmers and smallholders.

Regional variations exist in livestock production, with differences between the Delta region and Upper Egypt. Fahim *et al.* (2018) found that Upper Egyptian households typically owned no more than three buffaloes, compared to an average of ten in delta households. Buffaloes comprised 66 percent of ruminants in the delta but only 44 percent in Upper Egypt. Limited feed resources and infrastructure contribute to these lower numbers in both regions. Cattle are the second most prevalent ruminant, while sheep and goats represent 25 percent of herds in Upper Egypt versus 13 percent in the delta.

Livestock also plays a crucial, role in women's empowerment in Egypt. It is frequently one of the few assets women own or control, contributing to both household food security and providing a source of emergency income. This is particularly significant given that 71 percent of rural women work in unprotected, informal jobs, compared to 38 percent of men, with many working unpaid in family businesses (World Bank, 2024). While livestock offers women economic opportunities through the sale of animal products, only 5.2 percent of Egyptian firms are majority women-owned, and women's representation in decision-making roles remains limited.

2.2. Characterizing Egypt's main livestock and dairy production systems

Egypt's livestock sector is dominated by three distinct production systems (intensive, semi-intensive and extensive), each employing unique methods for raising and managing cattle and buffaloes. These systems significantly influence both the quality and quantity of livestock products.

Intensive Bovine Production: This system is characterized by its large-scale, high-input, and high-output nature. It represents approximately 6 percent of Egypt's total beef and dairy cattle and buffalo population (FAO, 2020), with around 14 000 registered farms. Herd sizes on these farms range from 100 to over 1000 animals (Goma and Phillips, 2022). Exotic breeds are commonly used on dairy farms, while meat production utilizes both exotic and crossbred animals. High productivity is maintained through access to sufficient financial resources for quality feed and veterinary services. Large-scale government vaccination campaigns further ensure animal health (Omambia *et al.*, 2017). Beef animals are typically sold through formal channels to butchers in major cities or directly to slaughterhouses. While crucial for Egypt's food security, providing a significant portion of the nation's milk and beef, the system's dependence on imported feed and potential environmental impacts present long-term sustainability challenges (Garnett *et al.*, 2009).

Semi–Intensive Bovine Production: This system represents a middle ground, employing modern production and husbandry practices but exhibiting variable efficiency levels. Herd sizes typically range from 10 to 100 cattle and buffaloes. It accounts for about 35 percent of all bovines in Egypt (FAO, 2020). Despite the use of modern techniques, inefficiencies persist due to factors such as inconsistent production practices, infrastructure limitations, and unregulated value chains. Improved local breeds are important in this system, chosen for their adaptability to the local environment and their efficient production of both milk and meat (FAO, 2017). Farmers in this system generally keep local breeds for both milk and meat production, with access to both private and public veterinary services. While they participate in government vaccination campaigns, they often rely on private practitioners for regular and emergency veterinary care, with limited access to governmental services (FAO, 2020a).

Extensive Bovine Production: This system involves smallholder farmers keeping a limited number of indigenous cattle and buffaloes (typically 1 to 10) alongside crop cultivation (Figure 1). It is characterized by low inputs and low outputs, with farmers having restricted access to production inputs, including veterinary services (FAO, 2020). The primary feed sources are berseem, corn leaves (darawa) and hay, with straw becoming more common during the summer. Milk produced within this system serves multiple purposes: household consumption, calf feeding, and local sales to neighbors or milk collectors. However, only a small fraction of the milk is processed into products like cheese and ghee (FAO, 2018). Although this system accounts for approximately 59 percent of all cattle and buffaloes in Egypt, accurate data is scarce due to the frequent lack of farm registration (FAO, 2020). The extensive system is vital for rural livelihoods, providing both income and a protein source for many households. However, low productivity and profitability persist due to a lack of proper management practices and inadequate breeding techniques (Hussein & Abd El-Rahman, 2012).

Traditional and integrated farming practices: Beyond these three primary systems, traditional family farming in Egypt often incorporates multi-species herds. These herds typically include large ruminants (cattle and/or buffaloes), small ruminants (sheep and goats), and sometimes camels in desert regions, along with backyard poultry (Aboul-Naga *et al.*, 2023). Under-irrigated farming systems in the delta and Upper Egypt, where forage crops like berseem and corn are cultivated, farmers often maintain mixed flocks of large and small ruminants (Abdelsabour *et al.*, 2022). In these irrigated areas, household milk consumption primarily relies on large ruminants. However, in the rain-fed tree-crop-small ruminant systems prevalent in the northwest coast of Egypt, a dynamic balance exists between tree and livestock investments, dictated by the climatic conditions of the year.

Figure 1. Small-scale farm in Behera

2.3. Impact of climate and feed availability on Egypt's livestock

Under Egyptian climatic conditions, livestock, particularly cattle and buffaloes, already experience significant heat stress during the summer months, and climate change is projected to exacerbate this issue, leading to reduced growth, milk production, and conception rates, and potentially increasing animal mortality (Goma & Phillips, 2021 and 2022). The Thermal Comfort Zone, where animals don't need extra energy to maintain body temperature, is between 5°C and 25°C for dairy cattle (Chichester and Mader, 2012). However, Egypt's geographical location and rising temperatures, often exceeding 40°C, combined with high humidity, extend the duration and severity of heat stress beyond this comfort zone (Goma & Phillips, 2022). This heat stress induces drastic biological changes, including reduced feed intake and efficiency, and disruptions in various metabolic processes (Habeeb *et al.*, 2018).

Challenge of animal feed availability and composition: Animal feed in Egypt is classified into green, dry, and concentrated types. Green feed, primarily Berseem (Egyptian clover), covers 48.4 percent of the total green feed area, and is cultivated across winter (89.3 percent of the cultivated area), summer, and Nile seasons. Dry feed utilizes crop by-products, predominantly wheat straw (90.3 percent of dry feed production). Concentrated feed, essential for growth, is either manufactured (from crushed seeds) or grain-based (bran being the most common at 31.2 percent, followed by corn at 28.1 percent) (Moussa *et al.*, 2011).

Egypt produces only 35 percent of its needs of the animal feed, relying heavily on imports. While the average annual feed production is 76.86 million tonnes (77.6 percent green, 13 percent dry, 9.4 percent concentrated) (Mohamed, 2023), and green fodder production is in surplus, a significant deficit of 7.34 million tonnes of concentrated feed exists (Al-Sharqawi *et al.*, 2019). This necessitates annual imports of approximately 9 million tonnes of maize, 3 million tonnes of cereals, and other feed additives (Shoukry, 2021). Each animal unit requires 3.3 tonnes of green feed, 800 kg of dry feed, and 1.33 tonnes of concentrated feed annually.

CHAPTER 3. Analysis of the dairy value chain in Egypt: landscape, actors, challenges, and climate change implications

3.1. Performance of Egypt's dairy subsector

Milk production is a significant component of Egypt's agricultural sector, accounting for 31 percent of the nation's total animal production value. Research by Sarhan and Al Dmarawi (2022) underscores considerable variability in milk output depending on animal type and geographical region, with the national average yield reported at 891 kg per head annually. The vast majority of this milk, 75 percent, originates from subsistence and traditional farming systems, collectively known as the informal sector. Within this informal sector, 45 percent of the milk produced is consumed at the village level. This local consumption is divided between calf rearing, which accounts for 25 percent, and use by farming families, which utilize the remaining 75 percent. The other 55 percent of milk from these traditional systems is considered a marketable surplus, reaching consumers through various channels including intermediaries and direct sales (ILO 2020).

The geographical distribution of milk production in Egypt show that the Delta region appears as the dominant producer, accounting for 55.6 percent of the country's total milk production, while the combined production of Upper Egypt and areas outside the Nile Valley accounts for the remaining 44.4 percent of total milk production. Foreign cattle breeds demonstrate markedly superior performance, with milk yields ranging from 2296 to 3258 kg/head/year. In contrast, local cattle breeds exhibit the lowest productivity, producing between 456 and 580 kg/head/year. Buffalo, a significant contributor to Egypt's dairy industry, occupies a middle ground in terms of productivity. While outperforming local cattle breeds, buffalo milk yields fall short of those achieved by mixed or foreign cattle breeds. This huge difference in productivity highlights the potential for improvements in Egypt's dairy sector, particularly in enhancing the genetics and management of local breeds to narrow the productivity gap with foreign breeds (Sarhan and Al Dmarawi 2022). Winter and spring are the milk production seasons in Egypt, accounting for 65-75 per cent of total annual production, due to availability of green fodder (berseem) during the period from October to June.

Egypt's per capita milk consumption has shown a significant historical increase over the past six decades. According to data from OWID (Our World in Data, 2024), Egypt's per capita milk consumption rose from 31.72 kg in 1961 to 49.32 kg in 2021, marking an approximate 55 percent increase. The substantial rise in Egypt's milk consumption likely reflects shifts in dietary patterns, economic development, and improvements in local dairy production and distribution systems. While Egypt has made significant steps, steps must be taken to address inefficiencies, constraints, and weaknesses across the entire dairy value chain (ILO 2020). This upward trend in milk consumption, as explained by El-Eraky *et al.* (2022), can be attributed to several factors. Rising per capita incomes have led to an increased demand for nutritious foods, including dairy products. Increasing awareness of the nutritional value of milk has also encouraged more frequent consumption. Additionally, the availability of long-life milk products, such as UHT-treated milk, has further supported this growth. Dairy products include fresh milk, ultra-high temperature (UHT) milk, yoghurt, cheese, ghee and other products. Santos Rocha *et al.* (2023) reported that Egypt imports more than 166 000 tonnes of baby milk and dehydrated milk that are extensively used in processing.

Climate change has had a negative impact on milk productivity in Egypt. It has been reported that a one-degree increase in temperature can result in a decrease of approximately 1.5 percent to 2 percent in milk production for Friesian cows in Egypt (Shaarawy *et al.*, 2023). A study in Kafr El-Sheikh governorate in the Northern Delta of Egypt showed a 39 percent reduction in total milk yield in Friesian cows during July and August, along with decreases in milk fat (7.92 percent) and protein content (4.06 percent) (Gaafar *et al.*, 2011). Future projections indicate a significant decline in per capita milk availability as a result of climate change, population growth, and reduced cow productivity (Goma & Phillips, 2021). Studies on buffalo calves showed daily body weight gain (DBWG) reductions of 22.6 percent and 16.5 percent at 36.0°C and 32.0°C, respectively, compared to 18.0°C, while bovine calves experienced DBWG declines of 52.8 percent (pure-bred) and 43.3 percent (cross-bred) in summer versus winter (Habeeb *et al.*, 2011 & 2014). The temperature-humidity index (THI) is a key indicator of heat stress, and increased THI levels have been linked to a 20 percent rise in abortion rates and a 10 kg reduction in average birth weight in Egyptian buffaloes (Omran & Fodda, 2023).

The dairy subsector faces climate-related challenges as a greenhouse gasses (GHG) emitter. While specific data on GHG emissions from Egypt's dairy subsector are limited, globally, dairy animals produce approximately 3.1 gigatons of CO_2 equivalent annually, representing 40 percent of total livestock emissions. A major component of these emissions is enteric methane, which accounts for 51 percent to 67 percent of dairy emissions, depending on the species and production systems involved (Gerber *et al.*, 2013).

3.2. Mapping stakeholders across the dairy value chain: Roles, challenges, and climate stressors

The dairy value chain in Egypt is a complex system involving a wide range of stakeholders. These stakeholders, including smallholder dairy farmers, large commercial farms, input suppliers, milk collectors, processing plants, and distributors, each play a vital role in the various stages of production, processing, and marketing. Mapping these actors provides a comprehensive understanding of the value chain's structure and helps to identify opportunities for private sector engagement in building climate resilience. Performance of the subsector is influenced by a broader ecosystem. This ecosystem encompasses supporting functions provided by actors such as business development, service providers and relevant research institutions. Furthermore, the relevant rules, regulations, standards, and laws significantly impact the performance and efficiency of the dairy milk production sector.

3.2.1. Analyzing core nodes in Egypt's dairy value chain

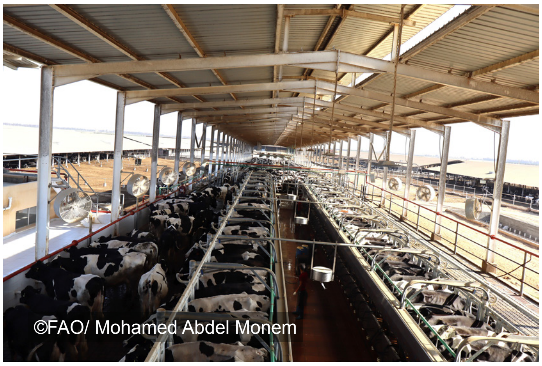
The analysis presented here is based on data collected and results from surveys conducted by the research team. These surveys targeted various nodes across the six targeted governorates and included key players in the Egyptian dairy processing sector. The findings provide insights into the core components and dynamics of Egypt's dairy value chain.

3.2.1.1. Milk Production

Egypt's milk production is characterized by a diverse range of farm sizes, each playing a distinct role in the dairy sector, as described in detail in chapter 2. Large, technologically advanced farms, though fewer in number, contribute significantly to the national milk supply and primarily serve major processors. Medium-sized, often-run farms are crucial for supplying both formal and informal markets and represent a substantial portion of the total milk production. The most numerous are small-scale, subsistence-level farms, which primarily serve local consumption or informal markets.

Large-scale dairy farms represent a significant segment of the nation's milk production infrastructure, operating as sophisticated, commercially driven enterprises. These farms typically house herds exceeding 100 cows, predominantly consisting of Holstein cattle imported from leading European and American sources. The survey in this study covers farms with more than 1500 cows. A core focus is placed on maximizing efficiency and productivity, resulting in an average milk yield of 32-35 kilograms per cow daily, sustained over an eight-month lactation period, and an annual yield of approximately 4700 kg per head. To achieve these levels, the farms integrate advanced technologies across their operations, encompassing automated feeding and milking systems, comprehensive veterinary services, and stringent hygiene protocols. Furthermore, maintaining the genetic purity of the herds is a priority, achieved through the utilization of artificial insemination with semen sourced from specialized international breeders.

Figure 2. Automatic milking system in a large-scale farm in Behira



Box 1. The Egyptian Milk Producers Association (EMPA)

EMPA, representing a network of 110 member farms, is a key organization dedicated to the support and development of the Egyptian dairy sector. EMPA's mission centers around advancing livestock development through several strategic initiatives. These initiatives include enhancing the quality of farm products, supporting the manufacturing of high-quality dairy products, and strengthening marketing efforts within Egypt and internationally. This includes export promotion and consumer awareness campaigns.

EMPA provides comprehensive support to its members, offering mutual aid during times of need, resolving disputes through mediation, and facilitating the import of essential resources, including live animals, feed, veterinary medicines, and farm equipment. EMPA also engages directly in dairy product manufacturing and marketing, ensuring that these activities generate mutual benefits for all its members. The association negotiates milk prices with large dairy companies on behalf of its members, using an agreed milk pricing equation that factors in changes in feed costs and indirect or management costs.

Medium–scale dairy farms: housing between 10 and 100 animals, these represent the backbone of Egypt's milk production, accounting for a substantial 60-70 percent of the national livestock population and contributing an impressive 75-80 percent of the total milk output. The field survey conducted under this study in the six selected governorates revealed that these farms typically raise a mix of livestock, including heat-tolerant buffaloes, crossbred Holsteins, and mixed brown cows. The animals are generally kept in open-air environments near the farmer's residence, fostering a close connection between the family and their livestock. Feeding practices are highly adaptable, with farmers carefully formulating measures based on animal needs, seasonal changes, and the availability and cost of ingredients. It consists of a combination of dry concentrated feed, green fodders like berseem and alfalfa, crop residues such as wheat and rice straw, and corn silage. Milk production varies between breeds, with mixed brown cows yielding 20-21 kg/day and buffaloes 7-9 kg/day, with differing lactation periods. Milk prices reflected regional variations, with higher prices generally observed for buffalo milk. Feed costs also varies by type and region, highlighting the economic complexities faced by these farmers. These farms usually sell their products through local markets or directly to dairy processors.

Small–scale subsistence farms: operated by micro landholders and landless farmers, these play a crucial role in the nation's milk production, and are characterized by their low productivity of about 750 kg per cow annually. The field survey shows that these farms manage small herds of 1-10 cows, including local breeds and varieties like crossbred Holstein, primarily for household consumption. The feeding strategies on these farms vary, with farmers using a mix of green fodder, concentrated feed, silage, alfalfa, corn, grain, and rice straw, though feed costs pose a significant challenge due to price fluctuations and inconsistent availability throughout the year. Disease outbreaks such as foot-and-mouth disease and ephemeral fever further threaten herd health and milk productivity, compounded by inadequate disease management and veterinary services. Additionally, rapid milk spoilage due to insufficient preservation techniques and a lack of organized marketing channels limits profitability, with farmers either selling to local dairy processors or through collection centers, and some engaging in on-farm milk processing.

3.2.1.2. Milk collection and aggregation

Middlemen: In the informal milk collection system, small-scale collectors (middlemen) with limited daily capacities (300-500 kg) act as crucial agents between smallholder dairy farmers and wholesalers. Operating within rural villages, these collectors aggregate milk from individual producers, averaging price and quality while transporting the product to urban markets. This system, whilst vital for connecting remote producers to the broader market, suffers from fundamental vulnerabilities. Farmers, often unable to access collection hubs or mini-dairies directly, receive lower prices for their small quantities of milk, while middlemen, facing high collection costs for these dispersed supplies, may resort to adulteration to maintain profit margins. This reliance on middlemen, therefore, introduces both price volatility and quality inconsistencies into the milk supply chain.

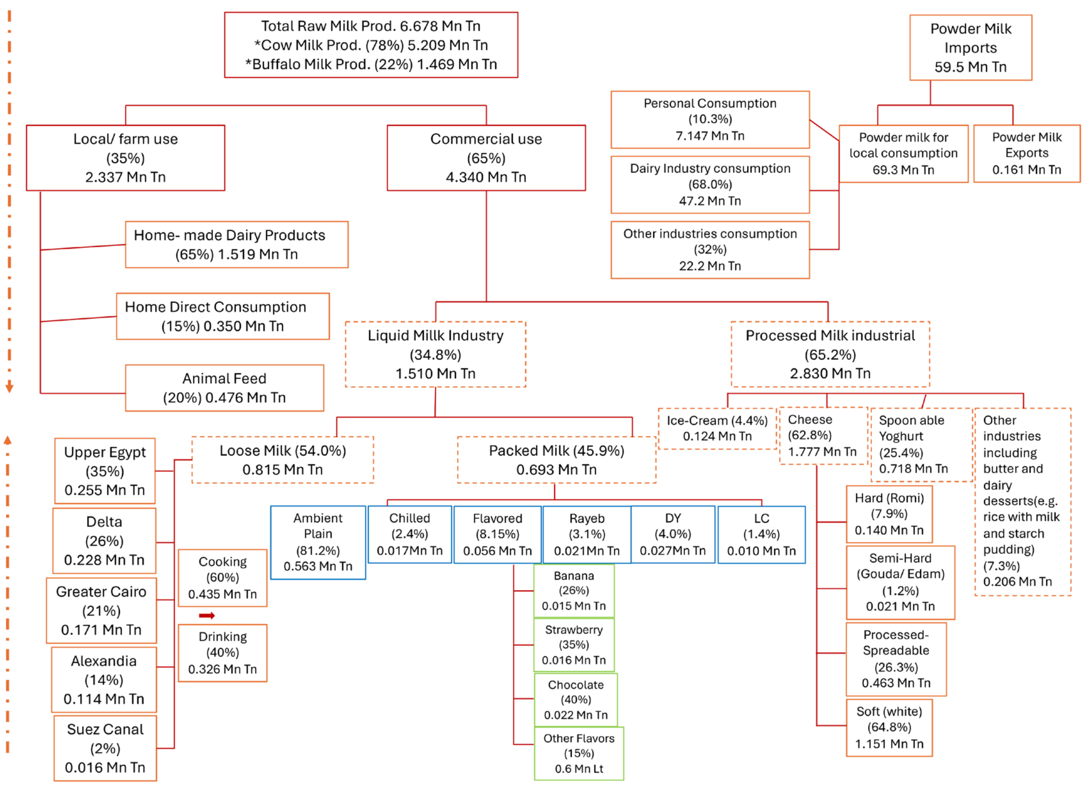
Milk Collection Centers (MCCs): established through state-cooperative initiatives, these have evolved into crucial elements of the dairy supply chain, initially serving small and medium-sized farms. Currently, over 1,000 MCCs are operational across the Nile Delta and Upper Egypt regions, showcasing varying levels of capacity and technological sophistication (ILO 2020). These centers are crucial not only as collection points but also as quality control hubs, equipped with cooling facilities and, in some cases, milk analysis equipment. Information collected through the survey in this study shows that, despite this progress, challenges persist, including regional differences in MCC distribution, particularly in Upper Egypt, which affect market access and milk quality control. The reliance on middlemen, while allowing market access to small-scale producers, often leads to price instability and quality inconsistencies, with some middlemen engaging in milk contamination to offset collection costs, thereby compromising product integrity.

Automated Milk Collection System (AMCS): In the large dairy farms surveyed, AMCS is employed to efficiently manage the milk harvesting process from high-producing cows that average between 32-35 kilograms of milk per day. This system utilizes automatic milking systems, which handle the entire milking process, including monitoring milk flow. Post-milking, the milk is immediately cooled to 4 degrees Celsius to preserve its quality and inhibit bacterial growth. It is then transferred through a sanitary, enclosed network of tubes directly to refrigerated milk trucks, ensuring minimal exposure to external contaminants. The AMCS is designed with strict hygiene standards, incorporating automated cleaning and sanitization processes, smooth surfaces for easy cleaning, closed systems to prevent contamination, and milk filters. Additionally, the system features sensors and data recording capabilities to track milk yield, milking frequency, and quality parameters for each cow. This technology not only ensures the production of high-quality milk with low bacterial counts but also enhances operational efficiency and supports data-driven herd management decisions.

3.2.1.3. Dairy Processing

Large dairy processing enterprises: important actors in the dairy value chain, processing products like milk, cheese, yogurt, and butter. These large-scale facilities, concentrated in areas of our field survey for Behera and Monofya, utilize advanced technology and automation for efficient and hygienic production. Processes include pasteurization, homogenization and fermentation, all controlled with accuracy to ensure safety and quality. These facilities source raw milk from local farms, including those with automated milking and cooling systems, or from their own farms, and distribute finished products through retail and export channels. The processed milk segment is divided into four primary categories: cheese production dominates at 50 percent of processed milk, followed by yogurt at 20 percent. Butter and ghee collectively account for 10 percent, while other dairy products—including concentrated milk, ice cream, and industrial ingredients—comprise the remaining 20 percent (FAOSTAT 2021). The diagram in Figure 3 represents Egypt's 2022 milk production and distribution, illustrating the division of the total raw milk into various usage categories, including direct consumption and industrial processing. It further details the percentages allocated to each segment and subcategory within those uses.

Figure 3. Flowchart of Egypt's dairy sub-sector



Source: Egypt Milk Map, 2022

Figure 4. Small-scale dairy facility in Beni Suef and Suhag

Major players in the Egyptian dairy processing sector: Less than 20 large firms often control dairy pricing in Egypt and have a substantial impact on the dairy market. There are over 300 private and public dairy production factories in Egypt. However only 10 percent of fresh milk produced in Egypt is manufactured through this modern large scale dairy production enterprises. The industry's growth supports local producers and contributes to the economy by creating jobs and reducing import reliance. However, challenges include fluctuating milk prices, the rising popularity of plant-based alternatives, and environmental concerns. Many factories are adopting sustainable practices, such as energy-efficient technologies and waste reduction programmes, to address these issues.

Small dairy processing facilities: comprising over 4000 plants, these are characterized by significant variations in processing capacity, ranging from 100 kg to over 10 tonnes of raw milk per day. Many of these producers, often located in rural areas and operating informally, struggle with challenges such as inefficient transportation, limited refrigerated storage, and insufficient milk collection centers, inconsistent access to formal market channels, and fluctuating milk supplies. Additionally, concerns about food safety arise from the use of unauthorized preservatives and limited regulatory oversight, which allows some producers to bypass quality and safety standards. Some small-scale dairy producers, like those in Beni Suef and Sohag (Figure5) as indicated by the information collected from the private sector survey, are creating their own recognized brands. The Beni Suef facility collects milk from small and medium-scale producers and farmers, while the Sohag facility uses milk from its own farm. Despite these successes, the sector's fragmentation and the prevalence of traditional production methods hinder its overall growth.

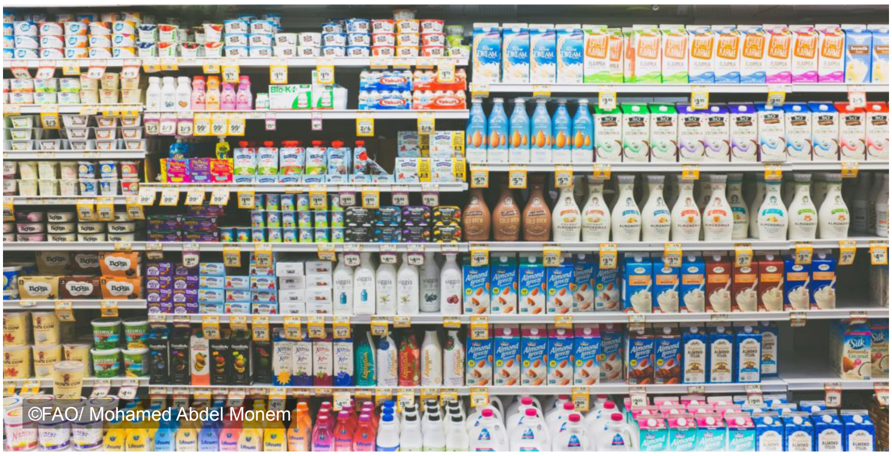
3.2.2. Supporting functions and key service providers

Dairy Marketing: The dairy marketing node encompasses the critical channels through which processed dairy products reach consumers. This node comprises several key actors:

- **Retailers:** Retailers form a fundamental link in the dairy value chain. These include supermarkets, local grocers, and informal market vendors. Large retail chains frequently have established partnerships with major dairy processors. Smaller retailers typically source products from local processors or, in some cases, directly from smallholder farmers. Egypt's large-scale dairy firms have developed extensive nationwide distribution networks. These networks incorporate modern, automated warehouses and substantial truck fleets, ensuring efficient and secure product delivery to a wide range of channels. These include hypermarkets, supermarkets, retail outlets, and wholesalers throughout the country (Figure 5). In rural regions, processors depend on retail shops and wholesalers as primary intermediaries to access consumers.
- **E-mmerce:** The dairy industry is undergoing a transformation with the expansion of e-commerce, introducing new dynamics and opportunities. Egypt's direct-to-consumer (D2C) market is poised for significant expansion, projected by 6Wresearch (2025) to grow at a 16.3 percent rate between 2025 and 2031, driven by a burgeoning middle class, increased internet penetration, and the surge in mobile commerce facilitated by widespread smartphone adoption and mobile payment systems. This growth is further supported by the younger generation's demand for personalized experiences and government initiatives promoting e-commerce. The dairy industry is also transforming through e-commerce and the rising D2C model, which enhances consumer connections, boosts online sales, and improves market access and convenience; consequently, the Egyptian dairy products e-commerce market is expected to see substantial growth.

- **Exporters:** Egypt's dairy sector exhibits a growing, albeit limited, export presence, concentrated primarily in processed goods such as cheese. Exporters collaborate closely with large-scale processors to ensure adherence to international quality and safety standards, thereby facilitating access to markets beyond domestic consumption.

Figure 5. Dairy products in Egypt



Input Suppliers play a crucial role in the dairy production process, providing essential resources and services to dairy farms. Key categories of input suppliers include:

- **Feed Suppliers:** Feed constitutes an essential input, especially for large-scale dairy operations. Suppliers offer a variety of feed options, including concentrated feed mixes and silage, which are vital for maintaining cattle health and productivity. Feed reliability and price are significant determinants of dairy farm profitability. Climatic impacts on feed crops, such as droughts, represent substantial risks to the supply chain.
- **Veterinary Service Providers:** Veterinary services are indispensable for maintaining herd health. This is particularly crucial for large and medium-scale farms, where disease outbreaks can have severe economic consequences. These providers deliver essential services such as vaccinations, artificial insemination, and general health care. These services are critical for ensuring productivity and long-term sustainability, especially in the context of environmental challenges.
- **Equipment Suppliers:** Suppliers of dairy farming equipment, including milking machines, cooling systems, and feeding equipment, are essential for enhancing operational efficiency and resilience. Equipment that mitigates the effects of climate change, such as cooling systems for heat-stressed cattle, is particularly valuable in regions with high temperatures, like Egypt.

Financial Institutions play a vital role in supporting the dairy industry by providing financial services and risk management tools. Key players include:

- **Banks and Microfinance Institutions:** These institutions provide essential credit and loan facilities to dairy farmers and processors. These funds enable investments in climate-smart technologies, feed, and veterinary services. Access to finance is particularly crucial for small and medium-scale farmers, who often lack the capital required for productivity-enhancing tools and technologies.
- **Insurance Providers:** Climate risk insurance is an increasingly important tool in the dairy sector. It helps de-risk investments by offering financial protection against extreme weather events, such as heatwaves or droughts, which can significantly impact milk production.

Government and institutional regulatory bodies, include several governmental and non-governmental organizations that play crucial roles in regulating, supporting, and advancing Egypt's dairy industry. These include:

- **Ministry of Agriculture and Land Reclamation (MALR):** The MALR has a central regulatory function within the dairy sector. It establishes livestock management and disease control policies, as well as feed quality standards. The MALR also supports research and development initiatives designed to enhance dairy productivity and improve resilience to climate change.
- **The Egyptian Milk Producer Association (EMPA):** EMPA's mission is to promote livestock development by enhancing farm products, supporting manufacturing, and expanding marketing activities, including exports. The association provides mutual assistance, resolves disputes, and facilitates the import of essential resources. Additionally, EMPA negotiates with major dairy companies to establish equitable milk prices for its members, utilizing a ‘milk price equation’ methodology.
- **National Research and Development Institutes:** These institutions are engaged in research focused on improving dairy productivity, animal health, and climate resilience. They collaborate with public and private sector entities to develop and disseminate climate-smart solutions applicable across the dairy value chain. This include, the Food Technology Research Institute (FTRI), established in 1997, plays a crucial role in knowledge transfer to the food industry, offering research and development, technical advice, and training tailored to client needs, including those in the dairy sector.
- **The Chamber of Food Industries (CFI)**, a non-profit established in 1958, represents the processed food and beverage sector, advocating for its members' interests, providing training, and promoting the industry domestically and globally.

CHAPTER 4. Perspectives from the private sector survey: climate risks and investment opportunities in Egypt's dairy sub-sector

This chapter utilizes findings from the private sector survey to analyze climate-related barriers and investment opportunities within Egypt's dairy production sector. Separate analyses are conducted for large and medium-sized enterprises, acknowledging the distinct challenges and opportunities faced by each group in the context of climate change. For large-scale private sector dairy producers, many of whom maintain integrated farming operations, a comprehensive survey served as the primary data source. This survey encompassed leading dairy production firms, including Juhayna, Almarai Egypt, Danone Egypt, Domty, Dina Farms, and Lamar. For medium-sized dairy farms, the private sector survey incorporated representative examples from various governorates, complemented by focus group discussions. To provide a comprehensive understanding, data were also gathered from the Chamber of Food Industries and the Animal Production Sector of the Ministry of Agriculture and Land Reclamation. By integrating these diverse data sources, the chapter analyzes current practices, identifies principal climate-related barriers, explores potential investment opportunities, and seeks to understand the specific adaptation needs of both large and medium-sized producers. Subsequent sections will elaborate on the specific findings, categorized by enterprise size, and discuss how they fit into the broader industry and policy framework.

4.1. Large–scale dairy farms

4.1.1. Climate risks

The operational setting of large-scale dairy farms in Egypt is significantly impacted by climate-related challenges, primarily heat stress. These farms often rely on high-yield exotic cattle breeds like Holsteins, which are particularly vulnerable to elevated temperatures. Holsteins perform optimally in cooler climates, but in Egypt, they are exposed to temperatures ranging from 30°C to 45°C for approximately 120 days annually. The survey conducted under this study revealed that owners of large-scale Holstein dairy farms reported a significant reduction in both milk yield and quality, particularly in terms of milk fat due to prolonged heat stress. This finding is supported by research from Altyeb *et al.* (2025), which showed that heat stress during summer months had a considerable impact on milk production in Holstein cows, with yields dropping from 38.81 kg/day in winter to 28.03 kg/day in summer, reflecting a substantial decline of 27.8 percent during the hottest season.

Beyond milk production, heat stress adversely affects overall cattle health, leading to reduced weight gain and increased mortality rates. To mitigate these effects, large-scale farms invest heavily in intensive cooling strategies, including ceiling fans, air-conditioning systems, and frequent cold-water showers as observed in the farms under survey, illustrated in Figure 6. While these measures help to alleviate some of the heat stress, they substantially increase energy and water consumption, increasing operational costs and placing additional pressure on Egypt's already-scarce water resources. Maintaining milk quality during transportation presents another challenge, as the higher temperatures necessitate the use of refrigerated transport systems to prevent spoilage, further adding to energy demand and operational expenses. The farms' heavy dependence on imported feed also makes them susceptible to global price fluctuations and supply chain disruptions, which are often exacerbated by climate change impacts in other parts of the world.

Figure 6. Fans and showers for Holstein cattle in Monofya

To cope with climate change, fans and showers are employed for Holstein cattle in Monofya

4.1.2. Opportunities in specific climate interventions

Despite the challenges facing large-scale dairy enterprises in Egypt, there are considerable opportunities for progress, particularly through innovative climate interventions. Investing in advanced cooling and heating systems, along with energy-efficient infrastructure, can significantly enhance resilience to climate change impacts. Implementation of sustainability initiatives, such as expanding the utilization of solar energy (already applied at some farms surveyed), implementing water recycling programmes, and adopting sustainable waste management practices for manure management were recognized by the surveyed stakeholders as cost reduction and environmental protection options. Furthermore, personnel within these large-scale enterprises have expressed a strong willingness to collaborate with international partners and participate in grant programmes. These collaborations are seen as vital for facilitating technology transfer, promoting the adoption of innovative production practices, and ultimately improving both operational efficiency and climate adaptation within the sector.

4.1.3. Barriers to investment

Several factors hinder investment and sustainable growth within the large-scale dairy farming sector in Egypt. A primary constraint is the high operational cost structure associated with maintaining advanced production levels to ensure profitability, often within narrow margins. A significant contributor to these costs is the heavy reliance on imported feed components, notably corn and soybeans, which exposes farms to the volatility of global commodity markets and currency exchange rate fluctuations. Waste management presents both environmental and operational challenges. Additionally, the labor-intensive nature of managing these large-scale operations, especially in maintaining cooling and biogas systems, adds to the financial burden. Contractual agreements with dairy factories, specifically concerning milk pricing, also pose ongoing challenges.

For example, investors at these large facilities are aware that biogas production from manure presents a significant opportunity to mitigate climate change that also can be used as organic fertilizer, as well as a source of electricity, heating, and even as a transportation fuel, offering a climate-smart alternative to conventional energy sources. However, despite these climate and economic benefits, there are significant barriers to adopting biogas in large-scale dairy farming in Egypt. Key challenges include limited access to financing and high interest rates, making borrowing expensive, and operational issues such as inconsistent manure supply and a lack of infrastructure for manure collection. A lack of standardized biogas quality and regulatory uncertainty further impede investment.

4.1.4. De-risking needs

Achieving sustainability and resilience at the large dairy companies, there is a need for multi-faceted de-risking approach, supported by various actors and stakeholders. Transitioning to more efficient cooling solutions to mitigate heat stress, moving away from the current reliance on water and energy-intensive methods, is a key initiative, as is diversifying feed sources by exploring alternative feed options or fostering local feed production to reduce dependence on imported components. To facilitate these changes, an effective financial ecosystem is essential. Banks and financial institutions play a critical role by providing capital for investments in climate-smart technologies and sustainable practices.

The development and utilization of carbon credit mechanisms can further incentivize emissions reductions, providing an additional revenue stream for companies that adopt environmentally friendly practices. These carbon certificates can act as a de-risking tool, making sustainable investments more attractive, and potentially improving access to financing. The Egyptian Stock Exchange (EGX) has established a platform for trading Carbon Emission Reduction Certificates (CERCs) as financial instruments, facilitating this market-based approach. Furthermore, establishing comprehensive insurance options is needed, expanding beyond simple livestock mortality coverage to encompass a wider range of production risks, thus offering financial protection against unforeseen events. Finally, proactive engagement with policymakers is important to direct regulatory changes and advocate for supportive government policies.

4.2. Medium–scale dairy farms in Egypt

4.2.1. Climate risks

Medium-scale dairy farms in Egypt face significant climate-related risks that impact both feed production and animal health. These farms, whilst often featuring more heat-tolerant breeds like buffaloes and cross-bred Holsteins, are still vulnerable to the effects of rising temperatures. Heat stress, especially during the summer months, directly reduces milk production and quality, even in these adapted breeds. Box 2 describes a model of the medium-scale dairy farms in Suhag.

Water and feed scarcity are major concerns, particularly in Upper Egypt. Owners and workers at the medium farms under the survey explain that droughts and extreme heat reduce the availability of essential green fodder, such as berseem and green corn leaves, forces farmers to rely on more expensive alternatives, often imported feed, impacting their profitability. The seasonal availability of green fodder already leads to inconsistent milk yields, with production peaking in the cooler winter and spring. Climate change is expected to shorten these cooler periods, aggravating the seasonality of milk production and further hurting farms' resources. Lack of adequate on-farm refrigeration leads to significant milk spoilage before the product can reach collection centers or processing facilities. Production of corn, a crucial ingredient in animal feed, is increasingly affected by rising temperatures and new pests such as the Fall Army Worm, leading to reduced yields and higher costs.

4.2.2. Opportunities in specific climate interventions

Medium-scale dairy farms have significant opportunities for growth and enhanced resilience through the implementation of climate-smart interventions. By adopting modern dairy technologies such as advanced milking equipment, cooling systems, and on-farm processing infrastructure, these farms can significantly boost productivity and improve milk quality. This modernization enables them to meet market standards and compete more effectively. Additionally, investing in climate-smart practices is crucial. These practices include improving animal housing to mitigate heat stress, implementing water-efficient irrigation for fodder production, and enhancing manure management systems. Stakeholders from the surveyed medium-scale farms have indicated that these measures not only enhance farm resilience against climate variability but also contribute to overall operational efficiency and sustainability. Utilizing agricultural residues as a source of animal feed provides a cost-effective and environmentally sustainable solution. Targeted training and capacity-building programmes—focusing on climate-resilient livestock management and modern dairy production techniques—are crucial for empowering farmers. Furthermore, the rising consumer demand for healthier, locally-produced, and traditional dairy products presents a niche market opportunity, making these community-focused farms with their upgraded small-scale dairy production facilities ideally positioned to exploit this trend.

4.2.3. Barriers to private sector investment in climate change solutions

Private sector investment in transformative climate solutions, particularly across Egyptian agriculture, agribusiness, and renewable energy, faces significant financial barriers, hindering the scalability of sustainable investments. These barriers primarily involve limited access to finance and high financing costs.

a) Limited access to finance: Several factors constrain access to finance for climate-related projects:

- Borrower risk (smallholder farmers): Egyptian smallholder farmers primarily rely on short-term working capital loans from the Agricultural Bank of Egypt. Access to capital expenditure financing for climate-resilient solutions is severely limited, hindering their ability to invest.
- Sector risk (agriculture): The agricultural sector is generally underfinanced. Commercial banks perceive it as high-risk due to volatile seasonal incomes, climate vulnerabilities, and complex land ownership structures, restricting access to long-term credit.
- Project-specific risk: Transformative climate projects are considered inherently risky due to long payback periods, substantial CAPEX requirements, and uncertain revenue streams, making banks and private lenders hesitant to provide financing.

b) High financing costs:

- Interest rates: High interest rates in Egypt make long-term borrowing prohibitively expensive, impacting the financial viability of capital-intensive climate-smart projects and discouraging private investment.
- Foreign exchange risk: Loans denominated in foreign currencies (USD/EUR) expose borrowers to substantial exchange rate risks. Fluctuations in the Egyptian Pound (EGP) can significantly increase repayment burdens, adding another layer of risk for investors.

4.2.4. De-risking needs

To effectively mitigate risks associated with medium-scale dairy investments, comprehensive strategy must tackle both financial and operational challenges. This can be achieved through facilitating connections to government-supported programmes, offering low-interest loans, and exploring microfinance initiatives designed to meet the specific needs of these farms. Such funding is critical for enabling investments in essential technology upgrades, infrastructure improvements (including on-farm cooling and storage), and broader climate adaptation measures, like improved water management and enhanced feed security strategies, also including comprehensive livestock insurance. This insurance is vital to protect farmers from substantial financial losses caused by disease outbreaks, extreme weather events, or other unforeseen circumstances, creating a more stable and predictable operating environment. Beyond pure financial measures, strengthening the operational resilience of these farms is equally important. This requires implementation of formal management practices, including detailed record-keeping, strategic business planning, and strong quality control systems. Capacity building and training programmes are needed to support the transition. These structured systems will enhance overall efficiency, improve competitiveness in the market, and contribute to the long-term resilience.

Box 2. A Model for Medium-Scale Dairy Farming in Suhag

In Suhag, an outstanding medium-sized farm owned by a young man called Mahmoud Tawfik serves as a model for similar agricultural ventures. This farm operates efficiently with approximately 100 head of livestock, which are managed on-site, eliminating the need for transportation. The farm spans 8 feddans dedicated to growing crops specifically designed to supply the livestock's feed mixture. Additionally, the farm boasts a modern dairy production facility equipped with up-to-date technology, ensuring high-quality dairy products (Fig. 8).

The farm is a family-run operation, with the owner and his family involved in day-to-day activities. They are supported by 10 skilled workers, creating a collaborative and productive environment. This integrated approach maximizes efficiency and productivity and promotes sustainability. The farm's success demonstrates the potential for medium-scale agricultural businesses to thrive with proper management and innovative practices.

Figure 7. Dairy value chain production system in Suhag

Dairy value chain production system in Suhag, with feed cultivation, cattle and buffalo production, and a medium-sized processing facility

CHAPTER 5. Climate-smart investment opportunities in Egyptian dairy

Analysis of the private sector survey, focusing on practical solutions with high adoption potential, revealed that a shift towards climate-smart technologies offers significant opportunities to enhance resilience and attract private investment in Egypt's medium-scale dairy sector. Surveyed stakeholders, including producers, processors, distributors, and technology providers, identified key innovations that not only mitigate environmental impact but also offer tangible business advantages. These include leveraging solar energy for electricity generation, water heating, milk chilling, and mobile cooling, with existing large-scale deployments demonstrating scalability for smaller farms. Efficient feed management strategies, such as silage and dry feed production, agricultural waste utilization, and advanced feed formulation, were also highlighted for their contributions to sustainability and productivity. Furthermore, biogas and fertilizer production from animal manure emerged as effective waste utilization methods with the added benefit of renewable energy generation. Finally, the growing market for plant-based milk was recognized as a sustainable and health-conscious alternative with a lower environmental footprint and the ability to cater to specific dietary requirements. The following section details these promising innovations, which offer a pathway towards a more resilient and sustainable dairy industry.

5.1. Agrivoltaics systems for dairy farms

5.1.1. Solar for electricity and hot water

Solar energy systems offer a transformative approach to dairy farm sustainability, delivering dual benefits of lower operational costs and a reduced environmental impact. These benefits are not merely theoretical; large-scale dairy farms in Monofya have already demonstrated success, with solar power supplying approximately 70 percent of their energy needs (Figure 8). These installations power critical operations, including milk processing equipment and water heating systems, which traditionally consume substantial amounts of energy. Beyond energy substitution, solar adoption offers multiple advantages for dairy producers. Farms implementing these systems have measurably decreased their carbon footprint whilst simultaneously reducing their dependence on grid electricity and fossil fuels. The resulting cost savings make solar particularly attractive in regions with abundant sunlight, creating a compelling return on investment despite initial installation costs. The Monofya success stories represent a significant market opportunity for private sector expansion throughout the dairy industry. The challenge now lies in scaling these solutions to medium and small-scale operations, which typically face more significant financial and technical barriers to adoption. Strategic partnerships between technology providers, financial institutions, and dairy cooperatives could accelerate this transition, creating more resilient and sustainable dairy production systems across all scales of operation.

Figure 8. Solar energy for water heating

Solar energy for water heating, generating clean energy, and as a shade for animals

5.1.2. Solar-powered milk chilling units

Solar-powered milk chilling units are an innovative solution for small and medium-scale dairy farmers, offering a cost-effective and environmentally friendly way to preserve milk quality whilst reducing greenhouse gas (GHG) emissions (Figure 9). These systems ensure efficient cooling and short-term storage of milk, minimizing bacterial growth and spoilage during on-farm storage and transportation. Using solar energy eliminates the need for fossil fuel-dependent refrigeration, making dairy operations more sustainable and lowering their carbon footprint. Beyond environmental benefits, these systems enhance productivity by maintaining milk quality and improving preservation, which translates into higher profits for farmers. They also contribute to local economies by enabling the manufacture of components like milk cans and other system parts, fostering business opportunities along the agricultural value chain. Solar-powered milk cooling technology represents a practical, scalable innovation for advancing sustainability and efficiency in the dairy sector.

Figure 9. Solar milk cooling in Tunisia

5.1.3. Solar-powered mobile coolers

Solar-powered mobile coolers present a groundbreaking solution to maintaining milk quality throughout the dairy supply chain, particularly in regions with limited infrastructure or unreliable grid access (Figure 10). These innovative coolers utilize solar energy to provide consistent and reliable cooling, preserving milk freshness and preventing spoilage during transportation, even in off-grid or remote areas. This significantly reduces losses due to temperature fluctuations and bacterial growth, contributing to increased profitability for dairy farmers and enhanced product quality for consumers. These units offer significant advantages. Small-scale farmers can transport milk efficiently from farm to collection centers or markets, while larger producers can maintain optimal temperatures over long distances. Furthermore, their eco-friendly operation, powered by renewable energy, reduces reliance on fossil fuel-powered refrigeration, minimizing the industry's carbon footprint and promoting a more sustainable approach to dairy preservation (FAO, 2022).

Figure 10. Solar powered mobile cooler in Kenya


©FAO/ Mohamed Abdel Monem

5.2. Efficient feed management

Efficient feed management in Egypt presents significant investment opportunities for both local and international stakeholders, especially within the private sector. As Egypt continues to modernize its agricultural practices, the livestock sector—particularly cattle farming—offers numerous avenues for growth, innovation, and profitability. The shift toward sustainable feed production systems not only meets the country's agricultural needs but also aligns with global trends in resource efficiency and environmental sustainability.

5.2.1. Silage and dry feed production

One of the primary areas ready for investment is the production of silage and dry feed. Egypt's cattle farming industry heavily relies on these feed types to maintain livestock productivity year-round, especially during seasons when fresh forage is limited. Private sector players can capitalize on this demand by investing in silage production facilities and dry feed processing plants. The growing need for high-quality silage, particularly from forage crops like maize and sorghum, presents an opportunity for agri-tech companies to introduce innovative storage and fermentation technologies. These investments can help ensure that Egyptian farmers have access to nutrient-dense feed throughout the year, reducing their dependence on imported feed and increasing the profitability of local feed production. Processing agricultural residues such as wheat straw and rice straw into high-quality dry feed can be a lucrative venture. Investors and entrepreneurs can explore the development of feed processing machinery, dehydration technologies, and distribution networks to serve the growing livestock market. By enhancing the efficiency of feed production, private sector players can tap into a market with growing demand due to the expanding cattle population and increasing focus on improving meat and dairy production in Egypt.

5.2.2. Agricultural waste for feed production

The utilization of agricultural waste in feed production is another area with immense investment potential. Egypt generates vast quantities of agricultural by-product, much of which has historically been discarded or burned. However, with growing awareness of sustainability and resource efficiency, there is a strong case for private sector engagement in waste-to-feed initiatives. Private companies can invest in feed processing plants that convert crop residues into valuable feed ingredients. This not only addresses the challenge of agricultural waste management but also significantly reduces feed costs for farmers, making it an attractive proposition. The demand for eco-friendly, cost-efficient feed solutions is growing as farmers seek to lower their operational expenses and improve the sustainability of their farming practices.

5.2.3. Advanced feed formulation and nutrition solutions

The increasing focus on tailored nutrition for cattle presents an exciting space for innovation and private sector involvement. As Egyptian farmers seek to optimize the health and productivity of their livestock, there is a growing demand for customized feed formulations that cater to specific production stages, such as lactation, growth, or fattening. Private investors, particularly those in the animal nutrition and feed technology sectors, can introduce advanced feed formulations and nutrient supplements designed to enhance cattle performance. Companies specializing in nutritional science can collaborate with local livestock farms to develop precision feeding programmes, which would ensure that cattle receive the appropriate balance of protein, energy, vitamins, and minerals. These solutions not only improve productivity but also reduce the overall quantity of feed required, leading to more efficient resource use. Introduction of digital tools and smart farming technologies for monitoring cattle nutrition and feed efficiency could revolutionize the sector. Private sector engagement in this space could include the development of mobile applications, data-driven feed management systems, and automated feeding equipment that help farmers optimize their feed strategies and reduce waste.

5.3. Biogas and fertilizer production from manure in dairy farms

Manure management presents a significant opportunity for climate-smart solutions within Egypt's dairy sector, particularly given the large quantities produced. For example, a single cow can produce between 15-35 kg of manure per day, depending on its size and diet. With an estimated cattle population contributing significantly to Egypt's milk production, this translates to a substantial volume of manure that, if improperly managed, contributes to greenhouse gas emissions. Specifically, the dairy sector's contribution to greenhouse gas emissions is notable, with approximately 3.1 gigatons of CO_2 equivalent produced annually by dairy animals, representing 40 percent of global livestock emissions. Enteric methane emissions, a major component, vary between 51 percent to 67 percent depending on species and production systems. However, converting manure into a resource offers multiple benefits. Anaerobic digestion of manure can produce biogas, a renewable energy source. The biogas yield from cattle manure ranges from 20-40 cubic meters per ton of fresh manure, depending on factors like digester design and operating conditions. This biogas can be used for heating, electricity generation (potentially offsetting fossil fuel use on farms), or even upgraded to biomethane for vehicle fuel. The byproduct, digestate, is a nutrient-rich fertilizer. It can replace synthetic fertilizers, which are energy-intensive, to produce and contribute to nitrous oxide emissions (another potent greenhouse gas). Proper manure management, through methods like covered storage or anaerobic digestion, can reduce methane emissions by 20-80 percent, depending on the technology and implementation. This directly contributes to climate change mitigation and can improve air quality. Furthermore, using digestate as a fertilizer can improve soil health and potentially increase crop yields by 5-15 percent, depending on the soil type and crop.

5.4. Plant-based milk

Plant-based milk is rapidly emerging as a crucial component of a climate-aware and sustainable food system, offering both mitigation and adaptation measures to address the climate change challenges facing livestock and dairy production, while also catering to specific health needs. Propelled by increasing consumer awareness of the health and environmental benefits, plant-based milk provides a compelling means to mitigate the ecological footprint of traditional dairy farming. Poore and Nemecek (2018) reinforce this, estimating dairy milk's greenhouse gas emissions to be three times higher than plant-based alternatives, with land usage nine times greater. Studies by Pingali *et al.* (2023) show that producing a liter of dairy milk requires considerably more land and water, and generates substantially higher greenhouse gas emissions, than producing the same amount of plant-based milk, such as oat, soy, almond, or rice milk (see Table 1 below). These metrics highlight that transitioning to plant-based milk can address key sustainability challenges, offering more resource-efficient pathways to meeting global milk demand. Plant-based milks offer a compelling alternative for individuals with certain dietary restrictions or health concerns. Lactose intolerance, affecting approximately 75 percent of the global population (Silva *et al.*, 2020), and cow's milk protein allergy, impacting 2-8 percent, primarily children (ibid), are two common conditions that can make consuming traditional cow's milk problematic. In Egypt, the prevalence of lactose intolerance is estimated to be around 68 percent (World Population Review, 2025), meaning a significant portion of the population could benefit from plant-based milk alternatives. Unlike cow's milk, plant-based alternatives are naturally lactose-free and cholesterol-free, making them suitable for those with these conditions, although individuals with soy or nut allergies should exercise caution.

Table 1. Environmental footprint indicators for dairy milk and plant-based milks

Indicator	Dairy Milk	Soy Milk	Almond Milk	Oat Milk	Rice Milk
GHG (kg CO_2-eq / 1 L product)	3.15	0.98	0.7	0.9	1.18
Land Use (m^2 / 1 L product)	8.95	0.66	0.5	0.76	0.34
Water use (L / 1 L product)	628.2	27.8	371.46	48.24	269.81

Source: Pingali, P., Boiteau, J., Choudhry, A., & Hall, A. 2023. Making meat and milk from plants: A review of plant-based food for human and planetary health. World Development, 170: 106316

In Egypt, this trend is reflected in the expanding market for plant-based milk, promoted by growing consumer awareness and the demand for healthier, more sustainable food choices. Local food production companies are responding to this demand by introducing diverse plant-based milk products catering to various dietary needs and lifestyles. This transition not only contributes to environmental sustainability but also raises economic prospects for local businesses and farmers. The Egyptian milk substitutes market, valued at USD 22.01 million in 2024, is projected to experience substantial growth, at an estimated annual rate of 16.87 percent, reaching a market volume of USD 47.98 million by 2029 (Statista, 2023). This growth underscores the increasing acceptance and integration of plant-based milks into the Egyptian diet.

CHAPTER 6. Economic appraisal and de-risking solutions

This chapter presents a comprehensive analysis of selected climate-smart interventions identified through a thorough assessment of market readiness, private sector interest, alignment with national climate strategies, scalability, and economic viability. These interventions are chosen from a broader range discussed in chapter 5. Economic assessment of these prioritized interventions provides realistic insights into their investment potential, identifies barriers to adoption, and proposes de-risking solutions to encourage private sector participation. The findings will contribute to a better understanding of the opportunities and challenges associated with transitioning towards a resilient and sustainable dairy sector in Egypt. This analysis builds upon insights gathered from the private sector survey and stakeholder consultations detailed in previous chapters. The prioritization of these interventions is based on the following key criteria:

- **Market readiness and private sector interest:** The selected interventions show existing market eagerness and active private sector involvement, indicating a higher likelihood of attracting further investment. This established foundation suggests significant potential for rapid scaling, provided that appropriate support mechanisms are in place.
- **Alignment with national climate strategies:** These initiatives are directly aligned with Egypt's national climate goals, as articulated in the Nationally Determined Contributions (NDCs) and the National Adaptation Plan (NAP), as well as with FAO objectives for sustainable livestock systems. Such alignment ensures that investments contribute to broader national development priorities and benefit from supportive policy frameworks.
- **Scalability and replicability:** The chosen interventions possess natural scalability and replicability potential across diverse geographical regions and farm sizes within Egypt's dairy value chain. This characteristic maximizes the potential for widespread impact and return on investment.
- **Clear and distinct economic model:** Each intervention is supported by a well-defined economic model that includes quantifiable investment costs, operational expenses, revenue streams, and measurable climate benefits. This clarity facilitates robust economic appraisal and informed decision-making for potential investors.

The prioritization of specific climate-smart interventions in Egypt’s dairy sector was guided by criteria such as market readiness, private sector interest, alignment with national climate strategies, scalability, replicability, and economic viability. In addition to these criteria, there are additional factors that support the selection process that led to the chosen interventions. Stakeholder feedback highlighted limited private sector interest in solutions like agricultural waste for feed production, as these are already informally managed by small farmers or NGOs in rural areas without scalable revenue potential. Seasonal fluctuations in agricultural processes further deter investment by creating inconsistent returns, particularly for small and medium-scale farms. The selected interventions were chosen not only for their economic feasibility but also for their transformative potential to address emissions reductions, energy security, and food security, while aligning with Egypt’s climate priorities. Given the scope of the study, a representative subset of interventions spanning waste management, energy use, and alternative production systems was analyzed in depth to provide actionable insights, with the approach remaining open to further refinement and future expansion.

Building on the previous analysis of prioritized climate-smart interventions, the following three specific focal areas for investment and innovation within Egypt's dairy sector emerge:

1. **Climate-Smart Manure Management:** This intervention emphasizes biogas production from animal manure through anaerobic digestion, providing a multifaceted approach to waste valorization. It mitigates greenhouse gas emissions by capturing methane while generating renewable energy, thereby reducing reliance on fossil fuels. Additionally, the process yields nutrient-rich digestate, serving as a valuable alternative to chemical fertilizers and promoting soil health.

2. **Agrivoltaics for Resilient Livestock Production Systems:** This integrated approach combines agricultural activities with solar energy generation on the same land area. Agrivoltaics offers a dual benefit: it mitigates climate change through renewable energy production and generates additional income streams for farmers through electricity sales. This diversification enhances the resilience of livestock production systems by reducing the reliance on single income sources and improving adaptability to climate variability.

3. **Sustainable Dairy Alternatives:** In response to growing consumer demand and significant environmental benefits, scaling up plant-based dairy production is identified as a key climate-smart practice. With a substantially lower carbon footprint and reduced land and water requirements compared to traditional dairy, plant-based alternatives present significant economic opportunities for private sector engagement, fostering both economic growth and environmental sustainability.

6.1. Climate-smart manure management: Biogas for energy & organic fertilizers

Project Overview

Biogas production from manure presents a significant climate-smart solution for Egypt’s dairy sector, offering both economic and environmental benefits. This project aims to install an anaerobic digestion system on a large-scale dairy farm with 3000 cows, converting manure into biogas for energy generation and organic fertilizer as a byproduct. The biogas can be used for on-farm electricity generation or upgraded into compressed biomethane for industrial or household consumers. The organic slurry serves as a natural soil conditioner, replacing synthetic fertilizers. While this economic assessment focuses on a large-scale farm, the model can be adapted for medium- and small-scale farms through tailored financing and operational strategies.

6.1.1. Economic assumptions and key parameters

The financial analysis is based on survey data and expert consultations with local stakeholders operating similar biogas plants in Egypt. The key assumptions are:

Project Capacity and Output

- Number of dairy cows: 3000
- Manure production: 45 kg per cow per day (~150 m^3 slurry)
- Anaerobic digester capacity: 200 m^3 per day
- Annual biogas production: 44000 MMBTU
- Annual reduction of methane emissions: 3000 tonnes of CO_2e.
- Organic fertilizer production: 5000 tonnes per year

Financial Assumptions

- CAPEX: USD 1.8 million (biodigesters, storage tanks, purification system, civil works, installation)
- OPEX: 1.5 percent of equipment costs annually (maintenance, labor, utilities, land rental)
- Biogas price: USD 4.5 per MMBTU (equivalent to natural gas price for manufacturing sector)
- Soil conditioner price: EGP 350 per ton (~USD 7 per ton)
- Financing structure: 30 percent equity, 70 percent debt (USD-denominated)
- Interest rate: 12 percent (commercial bank loan, 5-year tenure)
- Cost of equity: 16 percent
- Weighted Average Cost of Capital (WACC): 11.3 percent
- Project lifespan: 20 years

6.1.2. Economic viability (baseline scenario – without de-risking measures)

The initial financial model, without risk mitigation strategies, highlights significant investment challenges for private sector adoption.

Table 2. Baseline financial indicators for biogas production

Indicator	Result	Interpretation
Net Present Value (NPV)	($1.05 Mn)	Negative NPV indicates the project is not financially attractive under current conditions.
Internal Rate of Return (IRR)	2.2%	Below the WACC (11.3 %), meaning returns are lower than the cost of capital.
Payback Period	15.2 years	Too long for most private investors, given typical loan tenures of 5–7 years in Egypt.
Benefit-Cost Ratio (BCR)	0.43	Below 1, meaning costs outweigh benefits, making it financially unfeasible.

Key Challenges in the Baseline Scenario

- High upfront investment costs (USD 1.8 million CAPEX).
- Slow return on investment due to long payback period.
- Low biogas market demand in Egypt due to lack of carbon pricing incentives.
- Limited access to affordable financing for waste-to-energy projects.

Key Barriers to Investment

1. Financial and Economic Barriers

- Limited access to financing: High interest rates and lack of concessional loans for waste-to-energy projects.
- Biogas projects are perceived as high-risk investments due to the long payback period, high CAPEX requirements, and uncertain revenue streams.
- Unfavorable biogas pricing: The absence of carbon taxation on fossil fuels in Egypt eliminates financial incentives for manufacturers to adopt biogas over subsidized natural gas. While multinational companies in regions with emissions trading systems (ETS) may integrate biogas for compliance, the lack of a similar framework in Egypt restricts market demand. Consequently, biogas projects face challenges in securing off-takers, undermining their financial viability.

2. Operational and Market Barriers

- Infrastructure limitations: Many farms lack manure collection and storage systems.
- Seasonal manure variability: Dairy herd fluctuations reduce biogas production consistency.
- High collection and transport costs: The logistics of handling and moving manure to biogas plants is expensive due to lack of centralized collection.

3. Information and Capacity Barriers

- Limited technical expertise: Many farmers lack knowledge of biogas technology and operations.
- Low awareness of methane mitigation benefits: Farmers do not prioritize emissions reduction.

4. Policy and Regulatory Barriers

- Land Access & Permitting – complex bureaucratic procedures for obtaining land permits and environmental approvals.
- Lack of biogas certification standards: No official quality certification for biogas in Egypt.
- Regulatory uncertainty: No clear grid feed-in tariffs or government incentives for biogas energy.

6.1.3. De-risking strategies to improve investment feasibility

To enable private sector engagement, a combination of financial, operational, and regulatory de-risking measures is required.

1. Financial De-risking Solutions

- Blended Finance Facility: Mobilizing concessional capital from climate finance sources (e.g., Green Climate Fund, Development Finance Institutions) to lower borrowing costs.
- First-Loss Capital (FLC): Risk-sharing mechanism where climate funds absorb initial investment losses to de-risk private investments.
- Carbon Market Participation: Supporting project developers in accessing voluntary carbon markets for methane reduction credits.
- Long-Term Offtake Agreements: Encouraging multinational buyers to commit to premium-priced biogas purchases and Introducing preferential pricing mechanisms, ensuring biogas remains competitive with natural gas and enhancing revenue certainty.

2. Non-Financial De-risking Solutions

- Third-Party Biogas Operators: Partnering with waste management companies for project development and operation.
- Manure Supply Chain Development: Providing transport subsidies or incentives for manure collection.
- Biogas Quality Standards: Establishing national certification for industrial biogas use.
- Capacity Building Programmes: Training farmers on biogas technology and market integration.

6.1.4. Economic Viability with de-risking measures

By implementing financial incentives, premium pricing, and carbon credit monetization, the project's economic feasibility improves significantly.

Table 3. Revised financial indicators (with de-risking measures) for the biogas project

Indicator	Result	Interpretation
Net Present Value (NPV)	$775,000	Positive NPV, making it financially viable.
Internal Rate of Return (IRR)	12.5%	Exceeds the reduced WACC (8.1%), meaning returns are now attractive.
Payback Period	7.3 years	Reduced by half, aligning with private sector investment horizons.
Benefit-Cost Ratio (BCR)	1.42	Above 1, confirming overall project profitability.

Key assumptions in the de-risking scenario

- Reduced WACC to 8.1 percent, reflecting access to low–cost climate finance.
- Premium biogas pricing at USD 7 per MMBTU, secured through long-term contracts with industrial buyers.
- Carbon credit revenue included, monetizing methane reduction benefits.

6.1.5. Summary and conclusions

The climate-smart manure management project demonstrates significant potential for addressing Egypt's dual challenges of emissions reduction and sustainable agricultural development. Through anaerobic digestion technology, the project achieves substantial climate benefits by preventing approximately 13000 tonnes of CO_2e emissions annually while producing 5000 tonnes of organic fertilizer that reduces dependency on synthetic alternatives. This circular economy approach aligns with Egypt's climate commitments while supporting agricultural resilience. From an economic perspective, it is clear that, without derisking measures, the project was financially unfeasible with a negative NPV of USD 1.05 million and an unacceptable 15.2-year payback period. However, the implementation of strategic derisking interventions, particularly blended finance mechanisms and carbon market participation, transforms the investment landscape, yielding a positive NPV of USD 775 000 and reducing the payback period to 7.3 years. This dramatic improvement in financial indicators creates a strong business case for private sector engagement in climate-smart agriculture.

6.2. Agrivoltaics for a resilient livestock production system

Project overview

- Agrivoltaics, the integration of solar photovoltaic (PV) systems within agricultural activities, presents a climate-smart solution for livestock farming by enabling dual land use for energy generation and livestock production. This approach enhances farm energy efficiency, reduces carbon emissions, and improves livestock welfare by providing shaded areas that mitigate heat stress. This economic assessment focuses on a large-scale dairy farm with 1000 cows, selected due to its high energy demand for milking, milk cooling, water heating, ventilation, and automated feeding. These substantial energy requirements create a strong financial case for agrivoltaics solutions, as replacing grid electricity with solar power can generate significant cost savings.

- A successful precedent for agrivoltaics in Egypt exists at a dairy farm in Monofya governorate that was included in the survey under this study, where a similar project has demonstrated feasibility and scalability. Insights from this case study validate the assumptions used in this assessment and offer a replicable model for other livestock farms. This project involves installing PV panels over a reinforced shade structure, transitioning the farm's energy supply to 100 percent renewable electricity. The PV system will power daily farm operations, reduce grid dependency, lower electricity costs, and provide cooling benefits for livestock. By implementing agrivoltaics, the farm will replace 3000 kWh/day of grid electricity with solar power and reduce annual CO_2 emissions by approximately 515 tCO_2e, based on Egypt's grid emission factor (0.47 tCO_2/MWh).

6.2.1. Technical and financial assumptions

The project assumptions, including energy consumption, capital expenditure (CAPEX), and operational costs, are based on surveys and expert consultations conducted between January and March 2025. The assumptions include eliminating the need for costly battery storage while ensuring continuous power availability and the excess solar electricity to be fed into the grid for credit offsets, optimizing energy use.

Parameter	Value
Farm size	1000 dairy cows
Shade & shelter area	10 000–12 000 m²
Daily electricity consumption	3000 kWh
PV system capacity	680 kWp
Solar irradiance (Egypt)	5.5 kWh/m²/day
Performance ratio	80%
Required PV panel area	3,300 m²
Grid electricity tariff	EGP 2.00/kWh (subsidized)
Annual electricity savings	1,095 MWh
Electricity tariff escalation	10% annually
	CAPEX Breakdown
Financing structure	30% equity, 70% debt
Loan interest rate	28.75% (7-year EGP-denominated loan)
Cost of Equity	32%
Weighted Average Cost of Capital (WACC)	25.2% (before de-risking)
Project lifespan	25.2% (before de-risking)

6.2.2. Economic viability (baseline scenario – without de-risking measures)

The initial financial model, without risk mitigation strategies, highlights significant investment challenges to private sector adoption.

Table 4. Baseline financial indicators for the agrivoltaics project

Indicator	Result	Interpretation
Net Present Value (NPV)	(EGP 11.38 Mn)	Negative NPV indicates the project is not financially viable under current conditions.
Internal Rate of Return (IRR)	15%	Lower than the WACC (25.2%), meaning returns do not justify investment.
Payback Period	7.65 years	Longer than preferred by private investors.
Benefit-Cost Ratio (BCR)	0.54	Below 1, indicating costs outweigh benefits.

Key challenges in the baseline scenario

- High CAPEX requirements (EGP 24.95 Mn) make upfront investment burdensome.
- Low financial returns due to subsidized electricity tariffs, limiting cost savings.
- Long payback period discourages private sector financing.

Barriers to investment

Despite its economic and environmental benefits, large-scale adoption of agrivoltaics in Egypt faces several challenges:

1. Financial and economic barriers

- Limited access to financing for smallholder farmers due to high interest rates.
- High financing costs (28.75 percent interest rates) reducing the financial feasibility of renewable energy projects.

2. Operational and market barriers

- Farm infrastructure limitations: Most farms lack structural reinforcements to support PV panels, increasing CAPEX.

3. Policy and regulatory barriers

- Subsidized electricity tariffs reduce incentives for farmers to switch to solar energy.
- Unstable renewable energy policies, particularly fluctuating net metering regulations, create investment uncertainty.

6.2.3. De-risking strategies to improve investment feasibility

To enable private sector engagement, a combination of financial, operational, and regulatory de-risking measures is required.

Financial de-risking solutions

Blended Finance Facility: Mobilizing concessional capital to reduce borrowing costs.

I-REC Certification and Aggregation:

- Assisting farms in obtaining International Renewable Energy Certificates (I-RECs).
- Creating aggregation models for small farms to issue I-RECs collectively.
- Connecting farms with corporate buyers seeking I-RECs for sustainability commitments.
- Transparent Pricing & Market Access – Establish competitive trading mechanisms to enhance price transparency and maximize revenue potential.

Non-financial de-risking solutions

- Transparent and predictable net metering policy
- Ensuring stability in net metering regulations to provide long-term certainty for investors.
- Facilitating faster interconnection approvals to reduce bureaucratic delays in grid connection for on-site renewable projects.
- Establishing regulatory safeguards for surplus energy sales, ensuring guaranteed grid access and fair compensation for excess electricity fed into the grid.
- Electricity subsidy phase-out roadmap
- Announcing a clear and gradual roadmap for the removal of electricity subsidies for agricultural and commercial consumers.
- Providing transparency in tariff adjustments, including a published electricity price trajectory to allow investors to accurately model long-term returns.
- Facilitation of land and permitting processes
- Streamlining land access and permitting procedures for on-site renewable energy installations.
- Reducing administrative bottlenecks by expediting approval processes through coordination with relevant government authorities.

6.2.4. Economic viability with de-risking measures

By implementing financial incentives, premium pricing, and I-REC monetization, the project's economic feasibility improves significantly.

Table 5. Revised financial indicators (with de-risking measures) for the agrivoltaics project

Indicator	Result	Interpretation
Net Present Value (NPV)	EGP 7.69 Mn	Positive NPV, making the project financially viable.
Internal Rate of Return (IRR)	16%	Exceeds the reduced WACC (12.3%), improving investment attractiveness.
Payback Period	6.92 years	Reduced, making it more appealing to investors.
Benefit-Cost Ratio (BCR)	1.3	Above 1, confirming project profitability.

Key assumptions in the de-risking scenario

- WACC lowered to 12.3 percent, reflecting access to low-cost debt financing.
- Electricity tariff increases accelerated as part of economic reforms.
- I-REC revenue introduced, enhancing project profitability.

6.2.5. Summary and conclusion

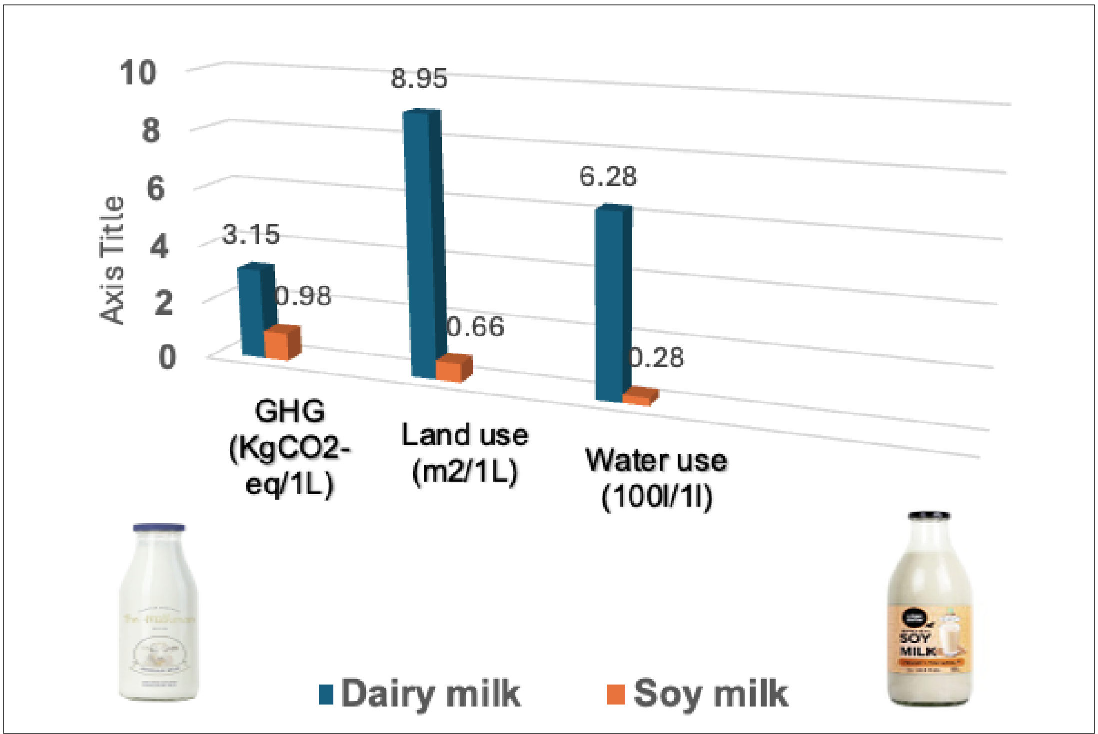
The integration of agrivoltaics in Egypt's dairy farming sector presents a dual opportunity to address climate change through significant CO_2 emissions reductions and to achieve enhanced economic returns following the implementation of de-risking measures. The proposed project, which involves installing photovoltaic (PV) panels over shade structures on a 1000-cow dairy farm, aims to replace 3000 kWh/day of grid electricity with solar energy. This shift is projected to reduce annual CO_2 emissions by approximately 515 tonnes, contributing directly to climate change mitigation efforts by diminishing the carbon footprint of the farm's operations. Initially, the project faces financial challenges, evidenced by a negative Net Present Value (NPV) of EGP 11.38 million and an Internal Rate of Return (IRR) of 15 percent, which falls below the baseline Weighted Average Cost of Capital (WACC) of 25.2 percent. However, the application of strategic de-risking strategies, such as blended finance mechanisms to lower the WACC to 12.3 percent, the phase-out of electricity subsidies, and the monetization of International Renewable Energy Certificates (I-RECs), significantly enhances the project's financial viability. Post-derisking, the revised financial indicators show a positive NPV of EGP 7.69 million, an IRR of 16 percent that exceeds the adjusted WACC, and a reduced payback period of 6.92 years. These improvements underscore the project's potential for generating attractive economic returns while simultaneously advancing climate goals. To fully capitalize on these benefits, it is imperative for policymakers and financial institutions to support such initiatives through favorable financing, regulatory reforms, and streamlined processes, thereby promoting sustainable development and substantial strides in combating climate change.

6.3. Plant-Based Dairy Production: A Sustainable Alternative

Project overview

- In Egypt, the plant-based milk market is emerging and experiencing rapid growth, fueled by increasing lactose intolerance rates and rising consumer interest in sustainable and healthy diets. However, the sector remains heavily dependent on imports, with local manufacturers primarily engaged in packaging and distribution rather than domestic production. Soy milk presents a unique opportunity for domestic production, given the relative availability of locally grown soybeans and successful trials by the Food Technology Research Institute (FTRI) in producing plant-based dairy products, including soy milk and tofu. Establishing a local soy-based dairy industry could enhance Egypt’s food security, reduce import dependency, create economic opportunities, and contribute to climate change mitigation.
- This project aims to establish a fully integrated soy-based dairy production facility in Egypt to process locally sourced soybeans into plant-based milk and tofu. Unlike existing players that rely on imported products, this facility will handle the entire production process, including soaking, milling, mixing, filtering, and homogenizing soybeans.
- The proposed project targeting the processing of 3000 kg of soybeans per day represents a 78 percent reduction in GHG emissions compared to traditional dairy, a 90 percent reduction in land use, and a 95 percent reduction in water consumption (Figure 11).

Figure 11. Environmental impact of dairy and soya milk – a comparison



Source: adapted from: Pingali, P., Boiteau, J., Choudhry, A., & Hall, A. 2023. Making meat and milk from plants: A review of plant-based food for human and planetary health. World Development, 170: 106316.

6.3.1. Technical, marketing and financial assumptions

Parameter	Value
Daily soybean processing capacity	3000 kg
Annual soy milk production (Phase 1)	2.475 million liters
Annual soy milk production (Expansion Phase)	7.425 million liters
Soy milk extraction efficiency	7.5 L/kg of soybeans
Egypt's plant-based milk market size	3.5 million tonnes/year
Market value of plant-based dairy sector	USD 22 million
Plant-based milk price (local production)	EGP 50/L (50% lower than imports)
Capacity of the production system	1000 Liters per Hour (LPH)
Estimated CapEx (processing & packaging)	USD 1.5 million
Facility construction & storage costs	USD 300 000
Financing Structure	30% equity, 70% debt
Loan Interest Rate (5-year EGP loan)	28.75%
Cost of Equity	32%
Weighted Average Cost of Capital (WACC)	XX% (to be validated)
Project Lifespan	10 years

Strategic Considerations

- Consumer Preferences: Extensive R&D investment to enhance taste, texture, and formulation for Egyptian consumers.
- Marketing & Awareness: 20 percent of revenues allocated towards consumer education, branding, and promotional campaigns in early years.
- Byproduct Utilization: Okara (soy pulp) repurposed for animal feed or food applications, enhancing sustainability.
- Future Expansion: Potential diversification into plant-based yogurts, cheeses, and fortified soy beverages.

6.3.2. Economic viability (baseline scenario – without de-risking measures)

The financial model under current conditions suggests the project is economically viable, but market adoption risks remain a challenge.

Table 6. Baseline financial indicators

Indicator	Result	Interpretation
Net Present Value (NPV)	EGP 69.4 million	Positive NPV confirms financial viability.
Internal Rate of Return (IRR)	40.72%	High IRR suggests strong returns, but CAPEX assumptions require validation.
Payback Period	3.84 years	Short payback period enhances investment attractiveness.
Benefit-Cost Ratio (BCR)	1.76	BCR > 1 indicates strong economic feasibility.

Key challenges in the baseline scenario

- Uncertain consumer adoption: Market penetration depends on taste acceptance and consumer education.
- Soybean cost volatility: Price fluctuations and import dependency impact production costs.
- Competition from imports: Imported products dominate the market with established brand presence.

Barriers to investment

1. Financial and economic barriers

- Niche market size with uncertain demand growth.
- Soybean price volatility and foreign exchange risks affecting production costs.

2. Operational and market barriers

- Dependence on soybean supply, which is subject to climate variability, import restrictions, and competition with animal feed production.
- Lack of established know-how for large-scale soybean processing into milk in Egypt.
- Potential inefficiencies in distribution and supply chain logistics, given the perishability of fresh plant-based dairy products.
- Consumer acceptance and potential taste preferences requiring additional investment in formulation and product development.
- Higher price point of plant-based dairy compared to traditional milk, potentially limiting market penetration.
- Limited awareness of plant-based dairy options among Egyptian consumers and hence the need for significant marketing and consumer education to shift perceptions and increase adoption.
- Potential competition from multinational brands with established market presence in plant-based dairy.

3. Policy and regulatory barriers

- Lack of clear regulations for plant-based dairy labeling and standards.
- Potential restrictions on using terms like "milk" for plant-based products.
- Import policy fluctuations affecting raw material availability.

6.3.3. De-risking strategies to enhance investment feasibility

1. Financial de-risking solutions

- Leverage government incentives: Utilize the 15 percent Industrial Financing Initiative to support local soybean processing.
- Pilot project grants: Secure funding to develop a commercial-scale prototype at the FTRI.
- Blended finance models: Implement first-loss capital structures with climate funds and DFIs to reduce investor risk.

2. Non-financial de-risking solutions

- Secure local supply chains: Develop contract farming models with soybean producers.
- Consumer awareness initiatives: Invest in education campaigns to promote plant-based dairy.
- Regulatory engagement: Advocate for clear labeling standards and supportive policies.
- Strengthen distribution networks: Form partnerships with retailers, online platforms, and food service providers.

6.3.4. Summary and conclusion

The establishment of a local soy-based dairy production facility in Egypt offers a compelling approach to mitigate climate change while generating attractive economic returns. The project, focused on producing soy milk and tofu from locally sourced soybeans, is projected to substantially reduce greenhouse gas emissions (up to 78 percent), land use (over 90 percent), and water consumption (more than 95 percent) compared to traditional dairy production. Initial financial projections indicate a positive net present value (EGP 69.4 million), a high internal rate of return (40.72 percent), and a short payback period (3.84 years), suggesting strong financial viability. However, market penetration and consumer acceptance remain critical challenges. De-risking measures, including leveraging government incentives like the Industrial Financing Initiative, securing grants for pilot projects and production upgrades at the Food Technology Research Institute (FTRI), establishing blended finance structures with first-loss capital, and forming strategic partnerships with agribusiness investors, are crucial for mitigating financial risks. Furthermore, non-financial de-risking strategies, such as developing contract farming models for stable soybean supply, implementing consumer-focused product development, engaging with policymakers for clear regulatory frameworks, and conducting consumer awareness campaigns, are essential for ensuring project success. By addressing these challenges, the project can unlock significant environmental benefits while contributing to economic growth, enhanced food security, and a reduced reliance on imports.

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Annex

Annex 1.

List of participants in the value chain survey in six governorates

No.	Name	Gender	Role in the value chain
	Menya		
1	Nada Nagah Moussa	F	Rural pioneer
2	Shaimaa Abd El-Ghani	F	Livestock breeder
3	Arabi Abdel-Malak Keliny	M	Executive Director - NGO
4	Charlie Salah Helmy	M	Feed trader - retail
5	Mona Abd El-Ghani	F	Livestock breeder
6	Emad Mina	M	Milk distributor
7	Evelyn Salama	F	Livestock breeder
8	Amira Gamal Charlie	F	Livestock breeder
9	Hend Gamal Charlie	F	Livestock breeder
	Beni Suef		
1	Tamer Abd El-Ra'f Mohammed	M	Livestock breeder
2	Entessar Mahmoud Mokhtar	F	Rural pioneer
3	Mohammed Hamed Mohammed	M	Small dairy processor
4	Omar Awadallah Abu El-Hassan	M	Small dairy processor
5	Ahlam Mohammed Ali	F	Small livestock breeder
6	Um Omar Sayed Khalil	F	Home dairy processor
7	Khamis Ahmed Sayed	M	Milk collection
8	Gomaa Ahmed Sayed	M	Milk collection
9	Eid Mahmoud Hasanein	M	Small dairy processor

No.	Name	Gender	Role in the value chain
	Sharqia		
1	Salwa Lotfi Abdel-Aziz Mahmoud	F	Small livestock breeder
2	Ibrahim Said Ahmed Mahmoud	M	Small livestock breeder
3	Abdullah Ali Mahmoud Ahmed	M	Medium livestock breeder
4	Ibrahim Arafat El-Sayed El-Aswad	M	Medium livestock breeder
5	Bakr Mohammed Ali Abdel-Halim	M	Small livestock breeder
6	Walaa Hassan	F	Home dairy production
7	Ahmed Abdel-Halim El-Deeb	M	Feed trader - retail
	Behera		
1	Youssef Ibrahim Abdel-Aziz	M	Livestock breeder - biogas unit
2	Nabil Abdel-Fattah Ismail	M	Medium livestock breeder
3	Afaf Kamel El-Kadeery	F	Home milk production
4	Fawzia El-Sayed	F	Home milk production
5	Rasha Ali Awad Mohammed	F	Small livestock breeder
6	Naama Abdel-Mawla Awad	F	Small livestock breeder
7	Mansour Ali Awad	M	Home livestock breeder
8	Hamed Ali Awad	M	Milk collection from homes
9	Mohammed Ismail	M	Feed and medicines trader
10	Ismail Abdel-Fattah	M	Feed and medicines trader
11	Ahmed Taha	M	Large dairy production company
No.	**Name**	**Gender**	**Role in the value chain**
12	Ahmed Hussein El-Sayed	M	Large dairy production company
13	Ali Youssef Ibrahim	M	Large dairy production company
14	Karim Mohammed Ahmed	M	Large dairy production company
15	Nabil Abdel-Rahman	M	Large dairy production company

No.	Name	Gender	Role in the value chain
Monofya			
1	Amr Salah	M	Large animal production company
2	Mohammed El-Hadi	M	large animal production company
3	Diaa Mohammed	M	Large animal production company
4	Sobhy Mady	M	Owner of large dairy farm
5	Mohamed Abdel-Aziz	M	Milk collection
6	Dr. Mohammed Hassan	M	Professor at faculty of veterinary science
7	Tarek Hassan Ali	M	Veterinary doctor
8	Dr. Adel Johar	M	University professor
Suhag			
1	Mahmoud Mohammed Tawfiq	M	Dairy production and distribution
2	Mona Mahmoud Ahmed	F	Dairy production
3	Nadia Hassanain	F	Dairy production
4	Reem El-Sayed	F	Animal production
5	Ibrahim Ismail	M	Dairy production and distribution)
6	Mahmoud Ahmed Ali	M	Agricultural feed production
7	Gaber Abbas	M	Large feed production factory
8	Osama Morsi	M	Large feed production factory
9	Majed Naeem	M	Small dairy distribution

Thirty-two percent of the number of persons interviewed were female.

Annex 2.

List of key stakeholders in the Egyptian animal production industry

No	Name	Entity
1	Dr. Tarek Soliman Head of Animal Production	MoALR – Animal production sector
2	Dr. Maisa Hamza & Dr. Reda Abd Elgalil	Chamber of Food Industries
3	Seif Thabet-CEO	Juhayna
4	Mohamed Seif-Procurement & Agro VP	Almarai Egypt
5	Hesham Radwan-GM	Danone Egypt
6	Mohamed Eldamaty-GM	Domty - Arabian Food Industries Co
7	Tarek Attia-Livestock Director	Dina Farms
8	Atef Saber	Agricultural Bank of Egypt
9	Chantal Sabaagh	National Bank of Egypt
10	Hatem El Gamal	Empower Capital
11	Mohamed and Omar El Demerdash	Engazaat
12	Dr. Shaker and Dr. Khaled	FTRI
13	Sobhy Madi	Farm Owner
14	Ghada Fouad	Beyti
15	Khaled Mekki and	E-Finance

Annex 3.

Dairy production value chain questionnaire

(Behera - Monofya - Sharqia - Menya - Beni Suef - Suhag)

General information	
↗ Name and job title: ↗ Type of organization: ↗ Nature of involvement in dairy products (role): ↗ Phone and email: ↗ Total members [women / men]:	
Introductory information about the dairy production system	
1	**What is the current herd size and number of animals in the project?**
	↗ Number of animals (Male … Female) ……………... ↗ Number of animals (Mature … Young) ……………..
2	**What breeds do you milk?**
3	**How many workers are assigned to the farm, including yourself?** Please record the numbers for both types of workers, even if the number is zero (0). Record yourself as a family member.
	↗ Number of family members ……………………. ↗ Number of non-family employees ………………
4	**How do you market most of your milk?**
	↗ Milk cooperative ↗ Milk collection center ↗ Independent contract with a dairy factory ↗ On-farm processing ↗ Others (please specify) …………………….
5	**What is your:**
	↗ Average production per animal (kg per animal per day)? ………………… ↗ Average bulk annual milk amount per farm? …………………...................
6	**Which of the following best describes your farm?**
	↗ Closed barn with traditional milking (hand milking) ↗ Closed barn with a milking machine ↗ Free barn with a milking parlor ↗ Other (please specify) …………………

7	**How did you obtain the animals (dairy) when you first established the dairy farm?**
	↗ I purchased them myself ↗ I inherited them ↗ Bank loan ↗ NGO loan
8	**Who owns the animals/farm? (You can choose more than one option)**
	↗ Husband ↗ Wife ↗ Both spouses
9	**Do you use the animals for producing milk or meat?**
10	**Type of animals:**
	↗ Local breed ↗ Hybrid breed ↗ Pure breed
11	**What type of feed do you give the animals?**
	↗ Concentrated feed (please specify ingredients) …………… ↗ Green feed (please specify) …………………… ↗ Legumes (please specify) ………………… ↗ Feed (please specify) …………………… ↗ Do you produce silage? Buy it? …………………..
	Understanding the Value Chain Landscape and Mapping the Private Sector Actors:
1	**Can you tell us about the dairy products market and value chain in your area?**
2	**What is your estimate of your region's share in the regional and global dairy products market? If you don't know, do you have a source that can provide details/data?**
	↗ Region's share ……………………… ↗ Source …………………………..
3	**What are the main destinations for dairy product exports?**
4	**From which countries does your region/Egypt import dairy products, if any?**
5	**What type of imports and how much quantity?**
	↗ Type of imports ……………………………..…. ↗ Quantity of imports ………………………………..

6	**Has the economic share/import/export of dairy products increased or decreased over the past ten years?**
	↗ Yes ↗ No
7	**Is demand/production increasing or decreasing?**
	↗ Increasing ↗ Decreasing
8	**What is the reason for the increase or decrease? If you don't know, do you have a source that can provide details/data (this is a question about trends)?**
	↗ Reason ………………………………………………………………….. ↗ Source …………………………………………………………………...
9	**Have there been significant losses in the dairy products industry in the past 5-10 years? If so, why?**
	↗ Yes ↗ No
	What are the primary uses of dairy products in your region/Egypt? What is their market share for these uses? Is there a local or international market for these uses? Example:
10	**Milk – Fresh dairy products – Processed dairy products**
	↗ Use …………………………………… ↗ Market share ……………………….. ↗ Local or international market ………..
11	**Local industries**
	↗ Use …………………………………… ↗ Market share ……………………….. ↗ Local or international market ………..
12	**Economic value of dairy products for you (percentage of total income)**
13	**Others**

Farm Productivity and Feed-Related Questions	
1	**Number of dairy cows and milk produced per cow (monthly)**
2	**Percentage of loss (unsold)**
3	**Total milk sold (tonnes/month)**
	↗ Average price per unit (kg/liter/ton) at the farm gate ....
	↗ Revenue (monthly income) ....
4	**Percentage of milk sold to manufacturers**
	↗ Percentage of milk sold to collection centers ....
	↗ Percentage of milk sold to the retail market ....
5	**Feed mixture for each cow monthly**
	↗ Concentrated feed (tonnes and %) ....
	↗ Corn silage (tonnes and %) ....
	↗ Legumes (tonnes and %) ....
	↗ Other (specify) ....
6	**Price of concentrated feed (per ton)**
	↗ Price of corn silage (per ton) ....
	↗ Price of legumes (per ton) ....
	↗ Price of other feed (specify) (per ton) ....
	↗ Total feed cost (monthly or per ton of milk) ....

Farm Consumption-Related Questions	
1	**Average cost of medicines/vaccines (monthly)**
2	**Number of workers**
	↗ Average worker cost monthly ....
	↗ Total labor cost ....
	↗ Management cost ....
3	**Cost of milking equipment (please specify owned/rented)**
	↗ Cost of utilities (electricity, gas, water, etc.) monthly ....
	↗ Cost of consumables (monthly) ....
	↗ Other costs (monthly) ....

4	**Total farm cost (monthly)**
	↗ Transportation cost (per ton) ………………………. ↗ Storage cost (per ton) ………………………. ↗ Milk profitability (per ton) ………………………. ↗ Additional information …………………………….
5	**Cost of a new cow (local breed)**
	↗ Birth rate ……………………………. ↗ Mortality rate (annually) …………………… ↗ Amount of manure (tonnes monthly) ……………………
	Climate Change and Its Impact on Dairy Production and the Dairy Industry
1	**What are the main actors in the dairy products, livestock, and feed value chain?**
2	**How does climate change affect the dairy products industry at different stages of the value chain? (Production, processing, distribution, marketing, consumption).**
	↗ Production …………………………………….. ↗ Processing …………………………………….. ↗ Distribution …………………………………….. ↗ Marketing …………………………………….. ↗ Consumption …………………………………..
3	**What specific climate-related challenges have you observed in dairy production, processing, distribution, and retail in your area?**
	↗ Drought ↗ Floods ↗ Pests ↗ Diseases ↗ Perishability
4	**What are the main risks faced by the value chain?**
	↗ How do these risks differ across different stages? …………………………………………… ↗ What needs to be put in place to mitigate these risks? ……………………………………… ↗ Why do you think these barriers exist? ………………………………………………………
5	**Are there any private companies already cooperating with donors or funders?**
	↗ Names …………………………………………………………………………
6	**How are these actors connected? Please explain the relationships from one stage to another.**

7	**How do dairy products flow from production to retail?**
	↗ Are there purchase agreements between producers and buyers (retailers)? ↗ Do processors install processing equipment for farmers on farms to reduce spoilage risks? ↗ Others
8	**Which stage of the value chain do you think is most important for the growth of the dairy industry and why?**
	↗ Production .... ↗ Processing .... ↗ Distribution .... ↗ Marketing .... ↗ Consumption ....
9	**What synergies exist across these dairy and livestock value chains, etc.? And how?**
10	**Which specific production companies, processors, or other actors in the value chain are most affected by climate change?**
	↗ How are they affected? ↗ b. If difficult to identify entities, highlight which stage of the value chain is most affected by climate change? ↗ c. Which actors significantly contribute to climate change or use unsustainable practices?
11	**What are the economic impacts of climate risks at different stages of the value chain? (Crop decline, export decline).**
	↗ Crop decline ↗ Export decline
Climate Solutions, Opportunities, and Barriers to Adoption	
1	**Which of the following climate solutions are most promising for the current private sector in your area? (Inquire about areas where they feel most interested among the proposed interventions).**
	↗ Strengthening and supporting drought and flood-adaptable animal and plant species and crops in mixed farming systems. ↗ Strengthening and supporting the improvement of post-harvest and post-milking handling, processing, storage, value addition, and marketing. ↗ Strengthening water harvesting and small-scale agricultural water techniques. ↗ If not these, what alternatives? And why?
2	**What are the main opportunities or growth areas for private sector involvement in these value chains?**

	↗ How can these barriers be overcome to improve the adoption of climate solutions?
	↗ What specific actions can be taken to enable actors in the dairy industry to effectively implement climate solutions?
	  ↗ Government policies
	  ↗ Financial incentives
	  ↗ Training programmes

3	**Where do you see opportunities for the private sector to engage and invest in transformational climate action?**
4	**What are the main constraints faced by private sector actors in the dairy industry in general? Inquire about some key challenges such as:**
	↗ Internal challenges ↗ Availability of human resource management ↗ Adaptation to technological changes ↗ Financial management/cash flow management ↗ Access to inputs ↗ External challenges: ↗ Compliance with regulations ↗ Supply and demand issues including customer expectations and market competition ↗ Economic uncertainty including market fluctuations and changing economic conditions
Risk Mitigation Solutions	
1	**What measures or strategies do you think can help mitigate the perceived risks associated with investing in climate solutions? Inquire about: policy or regulatory changes, financial incentives, etc.**
2	**What types of support or incentives would make value chain actors more likely to invest in climate solutions? Inquire about:**
	↗ Financial grants or support ↗ Loan guarantees on favorable terms ↗ Training and technical assistance in implementing climate solutions ↗ Access to new technologies or improved varieties ↗ Access to markets for products grown or produced using climate-smart practices ↗ Others
3	**Do you see a role for partnerships or collaborations between the public and private sectors in reducing the risks associated with investing in climate solutions?**
	↗ No ↗ If yes, how do you envision these partnerships working? ↗ Husband ↗ Wife ↗ Both spouses

The Support Programme on **Scaling up Climate Ambition on Land Use and Agriculture through Nationally Determined Contributions and National Adaptation Plans (SCALA)** is a five-years initiative led by FAO and UNDP, with funding from the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) through the International Climate Initiative (IKI). SCALA responds to the urgent need for increased action to cope with climate change impacts in the agriculture and land use sectors. The twenty million euro programme supports at least twelve countries in Africa, Asia and Latin America to build adaptive capacity and to implement low emission priorities.

Country support includes strengthening policies, adopting innovative approaches to climate change adaptation and removing barriers related to information gaps, governance, finance, gender mainstreaming and integrated monitoring and reporting. To achieve this shift, the programme engages the private sector and key national institutions.

SCALA supports countries to develop the capacity to own and lead the process to meet targets set out in their National Adaptation Plans and Nationally Determined Contributions under the Paris Agreement, and to achieve the Su ainable Development Goals. The SCALA initiative builds on another FAO-UNDP led programme, Integrating Agriculture in National Adaptation Plans (2015-2020). which has closed.

Food and Agriculture Organization of the United Nations
www.fao.org/in-action/scala/en

United Nations Development Programme
www.adaptation-undp.org/scala

International Climate Initiative (IKI)
www.international-climate-initiative.com

German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)
www.bmuv.de/en/

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