

Technical-economic Characterization and Typology of Peri-urban Dairy Farming Systems in Algiers (Algeria)

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Abstract

Faced with mounting uncertainties threatening the sustainability of dairy cattle farming in the wilaya of Algiers, understanding and improving existing production systems has become a pressing necessity. However, the characteristics of these systems remain insufficiently documented to effectively address current challenges. This paper proposes an original analytical framework aimed at assessing the situation of peri-urban dairy cattle farming in the wilaya of Algiers. A field survey was conducted from September to July of 2023, based on a non-probabilistic convenience sample of 59 breeders. Breeding practices were analyzed, a typology of production systems was established using principal component analysis (PCA) and an econometric model was developed to identify the determinants of farm inefficiency and prospects for improvement. The results reveal that dairy cattle farming is characterized by excessively high production costs, reaching up to 0.78 Euros/Dairy Cow/Day, against an average milk yield of only 17 L/DC/Day. These findings are attributable to inadequate public policies, the absence of an incentive-driven business environment and elevated livestock input costs that severely undermine producers' income. The results suggest that the modernization of dairy farming in the study region cannot be achieved within the current peri-urban agricultural framework. Production costs, identified as a key determinant of inefficiency, must be rigorously monitored and addressed through coordinated public action in order to achieve the expected performance improvements.

Keywords: Algiers, Livestock Practices, Performance, Peri-urban Agriculture, Production Cost, Typology.

Introduction

The livestock sector is among the most dynamic components of the global agricultural economy (1). In Africa, it plays a significant role in national economies, contributing on average 15% of Gross Domestic Product (GDP) and reaching over 40% in certain regions (2). In Algeria, it accounts for more than 30% of the agricultural GDP (3). In these developing countries, the sector contributes to household income, food security and nutrition (4, 5). Like many African nations, Algeria has a long-standing tradition in livestock farming, particularly dairy production. Since 1992, the government has launched several programs to revitalize the dairy sector, alongside significant investments (6, 7). These efforts have led to a substantial increase in milk production, though they have not sufficed to meet rising domestic demand. According to statistics from the Ministry

of Agriculture (2023), raw milk production rose from 1.64 million tons in 2001 to over 3.4 million tons in 2020, including 2.41 million tons of cow's milk, which currently covers nearly 60% of national demand. Today, Algeria ranks sixth in Africa among the top seven milk-producing countries, which together account for nearly 60% of the continent's total milk production (27.7 million tons) (4). Dairy farming has undergone significant transformations driven by substantial state efforts, particularly focused on the modernization of dairy farms. These interventions have fostered a noticeable dynamism and diversification in production systems, warranting closer examination. However, these efforts have not led to a well-structured production system, due to several limitations:

a) insufficient financial resources allocated to

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- technical modernization;
- b) inequitable distribution of public support within the dairy sector; and
- c) weak integration of local production into dairy processing chains (7-10).

Currently, dairy cattle farming in Algeria is predominantly practiced under extensive systems, particularly in the high plateaus and semi-arid zones, where water scarcity and high temperatures are key limiting factors (7, 11). A second system, intensive in nature, is based on the use of Modern Dairy Cattle Breeds (MDCB) and is more prevalent in high rainfall coastal areas near major urban centers. This system demonstrates relatively acceptable performance indicators in terms of yield, profitability and animal welfare (12, 13).

Within this context, the peri-urban area of Algiers selected as the study site presents an ideal case, as it holds considerable yet underutilized potential. Livestock farming remains a vital component of agricultural production systems in this area, contributing to soil fertility through manure spreading and diversifying farm incomes by valorizing fodder and crop by-products through milk sales. Focusing on peri-urban production systems aims to support farmers in optimizing their production assets and ensuring the sustainable and full utilization of their livestock resources.

Peri-urban dairy farming in Algiers is facing two major pressures. The first is economic, driven by rising production input costs and outdated livestock management practices, which increase production costs. The second is spatial, resulting from rapid urban expansion and the continuous loss of agricultural land, which drastically reduces the availability of forage areas.

Algiers, a Mediterranean coastal city characterized by a mild climate and fertile plains, offers favorable conditions for the development of peri-urban agriculture, which is already largely oriented toward specialized production such as livestock. Its economic and social relevance is reflected in its rich agricultural capital, numerous livestock facilities, skilled labor force and a high-performing dairy herd predominantly composed of high-yielding modern breeds. Furthermore, a dynamic and prosperous local dairy industry provides attractive outlets for milk producers and serves as a growth driver for the entire value chain (14).

More than two decades after the launch of the National Agricultural Development Program (PNDA) in 2001 later succeeded by the Agricultural and Rural Renewal Program (RAR) in 2009 it is now possible to draw some key lessons.

This article aims to

- a) characterize the dairy cattle farming practices and their relationship with the achieved techno-economic performances in the Wilaya of Algiers and
- b) identify potential pathways for future improvement within the framework of peri-urban agriculture.

To this end, a representative sample was selected to assess the conditions of dairy farming and to model the inefficiencies of these farms based on explanatory variables, with a view to informing public policy. The typological analysis conducted enables a comprehensive characterization of dairy farms and provides insights into their functioning, considering the constraints faced by dairy farming operations in peri-urban environments. By establishing a rigorous typology of dairy cattle farming systems in Algiers, this study sheds light on a critical component of the dairy sector that has remained largely unexplored by scientific research for more than two decades. Beyond providing a descriptive assessment, this work offers an essential decision-support tool for targeting public policies, anticipating land-use conflicts and laying the foundations for sustainable coexistence between urban development and dairy farming.

Methodology

Study Design and Methodological Approach

This research focuses on peri-urban agriculture, a form of agriculture that is both practiced and experienced within urban agglomerations by farmers and residents in relation to everyday life and the regulatory framework of urban planning (14). The selected sample reflects the reality of dairy cattle farming in Algiers, where most farms operate off-ground (confinement-based) dairy production systems.

Sample Selection

The selection of the Wilaya of Algiers was justified by its significant potential in dairy cattle farming, as illustrated in Figure 1. The region is home to more than 15,000 head of cattle, including approximately 8,000 dairy cows, over 85% of

which are of Modern Dairy Cattle Breeds (MDCB) (3).

In 2023, a total of 59 farms, comprising 422 dairy cows, were monitored through both qualitative and quantitative methods. The investigation was conducted using a comprehensive research questionnaire, administered across selected municipalities known for their dairy production potential in the Wilaya of Algiers namely Ouled Chebel (36.611° N, 3.006° E), Birtouta (36.643° N, 2.986° E), Tassala El Merdja (36.653° N, 2.898° E) and Douira (36.670° N, 2.944° E).

A pre-survey phase was carried out to assess the clarity and relevance of the questions, which helped refine the final version of the questionnaire

used for fieldwork. The questionnaire focused on socio-economic characteristics, farm structure and environmental context.

Each farm was visited at least three times: first, during the autumn season, then at the beginning of spring, a period characterized by feed abundance and finally, mid-summer, representing the feed shortage or "lean" period.

These targeted zones account for nearly 55% of the total milk production of the Wilaya and host a herd of approximately 5,000 head, of which 74% are MDCB (15).

The survey was conducted in the form of direct interviews, each lasting on average one hour.

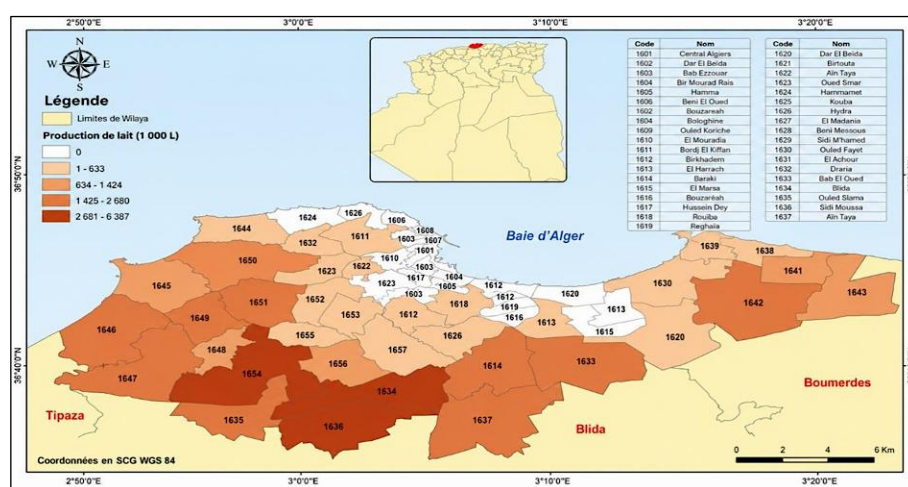


Figure 1: Distribution of Dairy Production Potential in the Wilaya of Algiers (15)

The farms surveyed in this study were selected using a non-probability sampling method, specifically convenience sampling. The selection was made in collaboration with milk collectors and deliverers to facilitate data gathering. This approach involves selecting individuals who are most accessible and available at the time of the study. The selected farms are primarily specialized in dairy cattle farming, which plays a predominant role in the overall income due to the economic weight of milk production. These farms typically rear imported specialized dairy breeds, mainly Holstein and Montbéliard, as well as locally crossbred cows. Pure local breeds are rarely found.

Analytical Framework

The analytical approach adopted in this study is based on a systems thinking approach, which allows for a comprehensive understanding of complex systems by emphasizing an integrated perspective over the exhaustive study of individual components. The analysis focuses on the interde-

pendence of the system's components and how systems evolve over time within the context of larger systems (16, 17).

In addition, the neoclassical theory of the production function was found to be particularly suitable for assessing inefficiencies in dairy farm performance. This theoretical model enables the evaluation of how production inputs are combined (18).

Efficiency has a direct impact on production costs, i.e., the cost of inputs required to operate a process. This is measured by the ratio of gross income to production cost, indicating the importance of gross income in relation to total expenses of the dairy farm. When this ratio approaches 1, the farmer is at the break-even point and must increase it to ensure profitability. In other words, efficiency reflects the return generated by each Algerian dinar invested in dairy farming after a production cycle.

A thorough understanding of the various costs associated with dairy production also makes it possible to assess cost price, profitability, competitiveness and the long-term sustainability of dairy operations.

The milk-attributed cost was calculated using Equation [1]:

$$\text{Milk-attributed costs} = \text{variable costs (operational)} + \text{fixed costs (structural)} - \text{by-products from the dairy unit (in DA/L)} \quad [1]$$

The prices of purchased inputs (concentrated feed, veterinary products, bedding materials, etc.) were recorded on the day of the survey and rechecked during subsequent visits for potential updates. Depreciation on investments related to dairy farming (purchase of animals, facilities and equipment) was estimated based on the following useful lifespans: 20 years for buildings, 10 years for heavy equipment (tractors, plows, silage

The production cost (PC) is defined as the total of all expenses incurred in raising livestock for milk production (19), including: capital investments, financial charges (taxes, insurance), other fixed costs, feed consumption, veterinary services, labor costs and so on.

harvesters), 5 years for light equipment (milking carts, cooling tanks, generators) and 7 years for dairy cows.

A reduction in production costs can, to a certain extent, result from increased production volumes, which assumes good cost control and financial awareness. An inventory of all annual sales of cattle, calves, manure and cull cows was conducted.

These sales represent co-products of dairy production and must be considered in calculating the unit cost of milk production, using the Equation [2]:

$$\text{Unit cost of one liter of milk} = (\text{milk-attributed costs} - \text{revenue from livestock sales}) / \text{total milk production (DA/L)} \quad [2]$$

The total costs and revenues were then adjusted based on the volume of milk produced per farm, allowing for the calculation of the average production cost per liter of milk.

Characterization of Dairy Production Systems

The second part of the study focuses on the characterization of dairy farming systems. A typology of the surveyed farms was developed based on selected variables derived from a correlation matrix, constructed using STATISTICA 06 software.

Belonging to the family of descriptive multivariate statistics, Principal Component Analysis (PCA) was used to reduce the dimensionality of the data while retaining as much relevant information as possible. PCA is particularly useful in contexts involving large and complex datasets. It also serves as a classification tool, allowing researchers to identify similarities among individuals in the same group and distinguish them from others (20).

Given the large volume of data and to avoid biased outcomes due to multicollinearity, we first computed a correlation matrix, then selected within each group of correlated variables the one that best reflected farm performance. This

procedure guided the selection of the final study variables, namely: net profit, gross profit, net profit margin, gross profit margin, production cost, unit cost of milk production, milk yield per cow, exceptional expenses (mortality), number of dairy cows, feed costs, labor costs, total feeding expenses and total production cost.

Results

Dairy cattle farming practices in the study area have a long-standing history and farmers generally possess a basic command of livestock management techniques. But what is the actual situation?

Technical Support for Farmers

Farmers in the region receive limited technical support from public institutions responsible for the development of the dairy sector, including the Directorate of Agricultural Services, the Chamber of Agriculture, technical institutes and training-extension centers. Only 13 farmers, representing approximately 22% of our sample, reported having participated in training workshops.

Representatives from these organizations, interviewed during the survey, confirmed that this limited support is mainly due to budgetary constraints imposed by the government. Unable to

provide quality technical guidance in innovation adoption, farmers struggle to implement new techniques and improve their practices. As a result, they integrate only marginally into the modernization dynamic of livestock farming initiated by public policies since 2009.

An Unfavorable Business Environment

Although the Algerian government has undertaken genuine efforts to diversify the economy and liberalize the financial system in order to foster a favorable investment climate (21), the business environment remains unattractive due to restrictive legislation, limited access to bank credit, inadequate agricultural insurance and taxation systems and lack of market transparency. These constraints hinder the proper functioning of the dairy value chain and affect dairy farms. For instance, only 17% of surveyed farmers who contracted bank loans for the purchase or renewal of pregnant heifers opted for insurance coverage, as required by bank eligibility criteria. The remaining producers rely on their own financial resources and show little interest in insuring their herds, despite the associated risks.

Archaic Production Conditions

The farm buildings observed during the study were diverse in structure, yet most did not comply with recommended dairy farming standards. Survey results indicate that 75% of the facilities were outdated and unsuitable for modern dairy production.

Small and Inadequate Dairy Farms

Although some farmers take pride in their facilities, dairy barns are primarily workspaces rather than prestige elements. In the study area, the average barn size was relatively small, with some farms operating in less than 50 square meters. Additionally, 85% of the facilities had asbestos-cement (Eternit) roofing. Wall materials were often low-cost cement blocks and while most floors were concrete, a few were still made of compacted earth.

Barns were poorly equipped, lacking even basic internal separations between calves and adult bulls. There is a critical need to upgrade these structures to meet modern livestock farming standards. Recent advances in construction materials - particularly eco-friendly, durable and lightweight technologies—offer a unique opportunity to reimagine livestock architecture (22). Such innovations can significantly enhance productivi-

ty, profitability and sustainability for dairy producers.

Loss of Agricultural Land: A Major Cost Driver

The Algiers plain has long been a symbol of prosperous agriculture and vibrant rural life, yet it has also witnessed a persistent encroachment of urbanization onto fertile farmlands (23). Today, an increasing number of city residents are relocating to the Mitidja region, further accelerating the loss of prime agricultural land.

As a result, land access has become a major constraint, forcing most dairy farming in the area to adopt confinement-based systems. Our study revealed alarming figures: the average landholding per farm is 2.7 hectares for 7 dairy cows, compared to 33 hectares for 48 Livestock Units (LU) including 30 dairy cows on typical European farms (24). This is less than half the land area of the European benchmark.

Predominantly Family Labor in Fragmented Farm Units

The type and duration of labor depend on the scale of farming. Larger farms may employ both permanent and seasonal workers, while most surveyed farms rely primarily on family labor, with external workers being rare. The number of permanent workers ranges from 1 to 3, including the farm manager.

Educational levels among farm operators were low: 39% had only primary education, 38% had middle school education, 15% completed secondary school and just 8% had university-level education.

There is a slow pace of technological modernization, due not only to a lack of material investment, but also to limited availability of skilled labor.

However, the study found that nearly half of the farmers (n=25) were under the age of 40 and over 71% were younger than 50, which constitutes a favorable condition for technology adoption.

In Western dairy models, the modernization of equipment and production techniques has led to substantial increases in labor productivity (25).

Analysis of Technical and Economic Performance

Dairy farming in the study area is characterized by a high diversity of production systems, which exhibit heterogeneous technical and economic performances.

Substandard Technical Performance

According to survey data, 88% of dairy farms raise fewer than 10 cows and nearly 45% have fewer than 5, underscoring the fragmented structure of dairy farms in the study region.

Previous studies indicate that the management of reproduction and herd supervision are major determinants of productive efficiency (26). Reducing non-productive periods in the animal's lifecycle is essential. Earlier research suggests that an optimal target is ten months of lactation and one calf per cow per year (27).

In the surveyed farms, heat detection is poorly managed, which undermines the success rate of artificial insemination (AI). Previous research has also highlighted the negative effect of inadequate heat detection on the success of AI (28). Although farmers resort to AI to save time and costs, the success rate for first insemination is only 40%. Consequently, many revert intermittently to natural mating, thereby increasing the risk of disease transmission, as the same breeding bull is often used by multiple farmers.

Additionally, 54% of farms reported dystocia cases, primarily due to poor-quality feed and inadequate fetal positioning. Calving rooms are rare; only 8 farms were equipped with one. In most cases, calving occurs in isolated corners of the barn on straw bedding.

The investigation also revealed frequent occurrences of pathologies such as mastitis and bloat. A lack of veterinary oversight was noted in over 80% of surveyed farms.

Regarding replacement heifers, 42% of farmers selected them from within their herds, based on the genetic potential of individual animals. This

practice highlights the need to promote the establishment of heifer nurseries, with support from specialized institutions.

Milking is performed mechanically in 55% of farms, typically twice a day.

Calves are fed maternal milk, which remains a common practice, driven by both preference and the unavailability of milk replacer powder.

All these livestock practices, far from reflecting modern approaches, illustrate the relative weakness in technical performance, confirmed by the high production costs.

Relatively High Production Costs

Calculating the cost of producing one liter of raw milk enables farmers to make strategic decisions about their operations by prioritizing cost items and identifying areas for efficiency improvement. Milk production costs are variable and depend on a combination of factors: farm characteristics, input prices and inter- and intra-annual climatic variability that affects forage availability (28).

The production cost structure presented in Table 1 indicates an average cost of 0.41 EUR per cow per day (based on an exchange rate of 1 EUR = 156 DA), with an average yield of 17.36 L/cow/day and a coefficient of variation of 58%. This reflects the significant disparities in production systems among farmers.

Nevertheless, the average yield observed is relatively higher than the national average, which is estimated at 12 L/cow/day according to the most recent study (29). However, the poor adaptation of imported breeds after introduction has limited the expected improvements in productivity, which have remained marginal and below potential.

Table 1: Structure of the Production Cost Per Liter of Raw Milk in Surveyed Dairy Farms During 2023

Cost Components ¹	DA/L	Percentage (%)
Depreciation of buildings	1.16	1.78
Depreciation of equipment	0.78	1.20
Depreciation of livestock	6.19	9.55
Financial charges (taxes, insurance, interest)	1.39	2.14
Other fixed costs	1.56	2.41
Total fixed costs	11.08	17.08
Exceptional charges (cow and calf mortality)	1.77	2.73
Feeding costs	36.90	56.89*
Veterinary and sanitary care costs	1.18	1.82
Maintenance and hygiene expenses	1.74	2.68
Energy and water consumption costs	0.20	0.31
Labor costs	12.00	18.49*
Total variable costs	53.79	82.92
Total production cost	64.86	100.00

Note: ¹Cost components are expressed in Algerian dinars per liter of raw milk (DA/L) and as a percentage (%) of the total production cost. * indicates the main cost components contributing to total production costs.

The cost structure clearly highlights the predominance of feed expenses, which account for nearly 57% of the total production cost. Labor costs, on the other hand, represent approximately 18%, reflecting the significant reliance on manual labor across most of the surveyed farms. These figures emphasize the labor-intensive nature of dairy farming in the study area and the limited mechanization observed.

Typology of Dairy Farms Based on Principal Component Analysis (PCA)

Based on the variables previously identified and presented in Figure 2, a typology of the surveyed dairy farms was developed and analyzed using the STATISTICA06 software. The classification enabled the grouping of farms into four [04] distinct types of dairy production systems, primarily based on production cost and net profit.

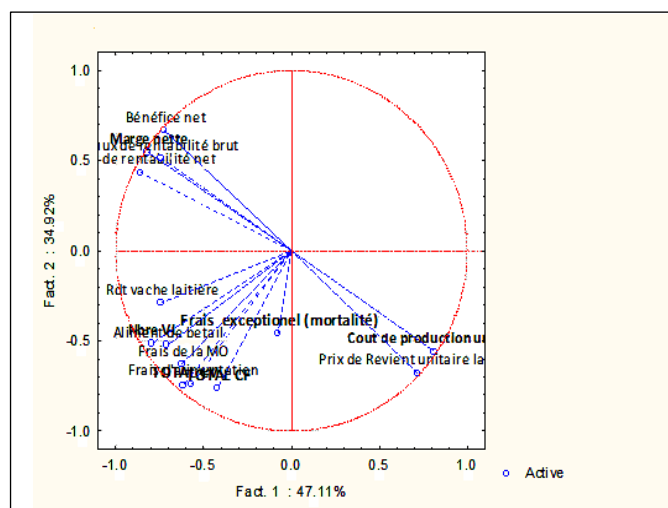


Figure 2: Results of the PCA Variable Projections (Projection of Variables on the Factorial Plane (1 × 2). Fact. 1 (47.11%) and Fact. 2 (34.92%) represent the first and second factorial components, respectively. The axes indicate the proportion of variance explained by each component. The vectors represent the contribution of each variable to the components.

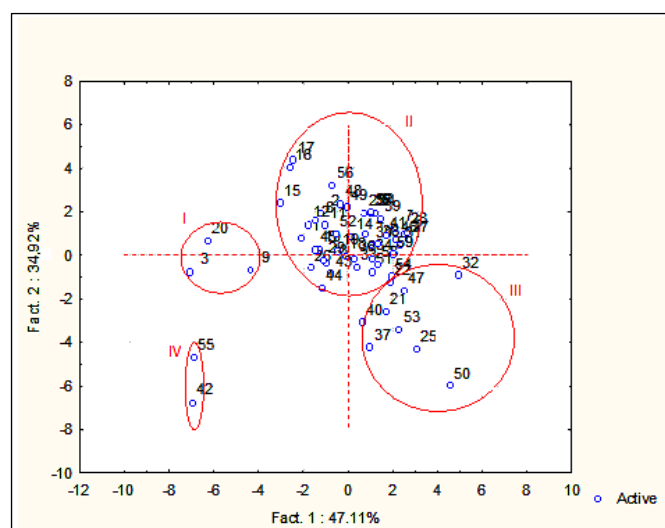


Figure 3: Results of the PCA Individual Projection (Projection of individuals on the Factorial Plane (1 × 2). Fact. 1 (47.11%) and Fact. 2 (34.92%) represent the first and second factorial components, respectively. The observations are represented according to their coordinates on the factorial plane, while the four groups (I–IV) correspond to the distinct groups identified by the analysis. The proximity of observations on the factorial plane indicates similarities in their overall characteristics.

With a high quality of representation of approximately 82%, it can be stated that the main variables serving as classification criteria are: unit production cost per liter of milk and net profit of the farm. These variables enable the development of a typology of dairy farms, as illustrated in Figure 3.

The results of the PCA individual projection presented in Figure 3 revealed four distinct groups based on the two selected variables.

a) Group I: This group includes three farms with the highest net profit (approximately 29 DA/liter) and the lowest production cost, around 39 DA/liter - nearly half the average cost of the sample (74 DA/liter). This group is the most efficient among the sample. The general characteristics of these dairy farms, presented in Table 2, indicate that dairy production is their main activity.

These farms employ qualified external labor, regularly participate in professional events, training sessions and capacity-building workshops. They benefit from high-quality infrastructure and practice a production model requiring significant feed input - up to 500 kg of concentrate per cow per year—and are characterized by high-yield imported breeds, producing between 270 and 500 kg of milk per lactation.

b) Group II: This group represents the largest proportion of the sample and corresponds to the typical farm type in the study area. With an average production cost of 71 DA/liter, close to the sample mean, it shows a negative profitability of around 26 DA/liter.

These farms show limited or no interest in technical innovation or training and rely on production diversification. In 68% of the cases, herds consist of no more than 10 dairy cows, primarily managed by family labor under moderate production conditions.

Cows are of locally improved breeds, with few imported dairy breeds. Grazing typically occurs on private or communal land (municipal or public structures), located 1 to 3 km from the stables. About 55% of farmers own a small UAA (Utilized Agricultural Area) ranging from 0.5 to 2 ha, while the rest have 2 to 10 ha.

c) Group III: This group is composed of the least efficient farms, with the highest production cost of 95 DA/liter, far above the sample average and the lowest net profitability, estimated at -57 DA/liter. These farms exhibit no interest in training, professional networking, or infrastructure improvement. They rely almost entirely on strictly family labor, with minimal investment. For all farms in this group, livestock and product sales or bartering represent the main income source. Only 45% of these farmers report earning income from milk sales.

d) Group IV: A very small group (only two farms) with high milk production levels (more than 20 liters/day), a relatively low production cost (56 DA/liter) and mildly negative profitability. Despite showing temporary inefficiency, these farms have better production conditions and have made notable investments. Their current performance suggests that, over time, they may converge toward Group I, the efficient group.

Table 2: General Characteristics of the Studied Dairy Farms

Groups	Percentage (%)	Average Herd Size	Profitability Rate (DA/l) ²	Production Cost (DA/l) ³	Production Type Classification	Type of Labor
Group I	5.1	23	29	39	Specialized in dairy production	Highly qualified external labor
Group II	76.3	5	-26	71	Mixed production	Family and occasional labor
Group III	15.2	7	-56	95	Mixed with focus on cattle resale	Strictly family labor
Group IV	3.4	28	-9	56	Specialized in dairy production	Specialized external labor
Average	100	—	—	74	Mixed production	Family and occasional labor

Note: ²Profitability Rate (DA/l): Net margin per liter of milk (selling price - Production cost). ³Production Cost (DA/l): Total cost of producing one liter of milk, expressed in Algerian Dinars.

To support our argument, we conducted a multiple regression analysis to highlight the relationship between the profitability rate and various production inputs in the studied dairy farms. The

$$TXRTBLT = -102.51 + 1.47 NBR VL - 0.27 FRMORT - 0.67 FOIN - 0.81 F/MO + 0.58 RDT VL \quad [3]$$

Where, TXRTBLT = Profitability rate, NBR VL = Number of dairy cows, FRMORT = Mortality-related expenses, FOIN = Forage (hay) expenses, MO = Labor costs, RDTVL = Milk yield per dairy cow.

This model clearly indicates that achieving high efficiency and better resource utilization in dairy farming operations requires a relatively large herd size, effective control over feed expenses, proper herd management and optimized labor costs.

For comparison, the French experience demonstrates that improved yields have significantly reduced production costs, making the dairy farming sector more profitable. This improvement is largely attributed to the modernization process, which has driven up productivity and efficiency (24).

Unfortunately, such results are not observed in the studied farms, despite the support provided by the Algerian government through various development programs aimed at boosting milk production.

Discussion

The study of the efficiency of dairy farms located in the Wilaya of Algiers reveals a concerning situation for public authorities. Even when accounting for the sale of by-products, the overall economic outcomes remain largely unchanged.

Indeed, the efficiency measure employed enabled us to identify farms that, despite displaying average technical performances, show poor economic efficiency. In other words, while technically adequate, these farms are not economically viable. Out of the 59 farms surveyed, only six were found to be truly profitable.

The inefficiency observed in the dairy cattle farms in the study area stems from several critical factors:

A Relatively Small Herd Size: According to the survey results, the small scale of livestock operations does not favor efficient production. This limitation is further exacerbated by rapid urban expansion and an unfavorable socio-economic environment.

An Uninviting Business Climate: The business environment surrounding dairy farming is not conducive to investment. The current regulatory framework is highly restrictive, insurance services

resulting model, presented in Equation [3], explains nearly 80% of the observed profitability rate, with a negligible margin of error:

remain unreliable, the banking system is underdeveloped, markets lack transparency and contractual arrangements are ill-suited to the needs of dairy producers.

Algeria ranks 157th globally, reflecting a discouraging economic environment that poses significant constraints to development. These same constraints significantly hinder the overall development of the dairy sector and dairy farms.

Low Productivity of the Production Factors

Used: Farm performance varies considerably. This inefficiency is partially explained by a lack of adherence to technical protocols and the mismatch of production inputs. Among the technical shortcomings identified during the survey, heat detection was not adequately mastered by many dairy farmers, although it is a key determinant of successful artificial insemination and reproductive performance. Inadequate heat detection was previously identified as a major constraint affecting reproductive efficiency in Algerian dairy farms (26). More recently, inaccurate estrus detection has remained one of the major causes of poor reproductive efficiency in dairy cattle worldwide. The review emphasizes that traditional visual observation, still widely practiced on farms, often lacks reliability because of silent estrus and the subjective interpretation of behavioral signs by farmers (30).

In addition, the limited effectiveness of agricultural extension and advisory services restricts the dissemination of technical innovations and the provision of high-quality guidance to dairy farmers. As a result, producers encounter difficulties in adopting improved production techniques and implementing recommended management practices, which further constrains farm performance. The evolution and, in some cases, the shortcomings of agricultural advisory and extension systems considerably limit farmers' ability to appropriate and implement new technologies (31). According to these authors, without appropriate technical support and

continuous advisory services, innovation remains inaccessible or is frequently rejected by farmers, thereby hindering the adoption of improved agricultural practices and reducing farm performance.

In terms of farm management, producers employ strategies such as cost reduction and market diversification through mixed systems (meat/milk) and the sale of calves, heifers and even milking cows. Risk sharing continues to be the dominant strategy adopted by these farmers.

A key driver of inefficiency is the high feed cost, which accounts for 57% of total production expenses. The lack of investment and the significant labor costs reflect the persistent dominance of manual labor, which characterizes most farms. The farm-gate milk price remains a source of tension among stakeholders.

Overall, the dairy farms studied are multi-purpose operations. Cows are often raised under precarious conditions and fed an unbalanced diet, consisting mainly of straw, bran and limited green fodder. These non-specialized production systems exhibit unstable and short-term trends, which stem from their structural weaknesses (32).

Furthermore, the limited productive performance observed may also be explained by the inadequate adaptation of imported dairy breeds to local production conditions. Despite the introduction of high-yielding exotic breeds to improve milk production, their productive potential has remained largely underexploited because of climatic, nutritional and management constraints. Despite the widespread use of imported dairy breeds in Algeria, farm performance often remains below the animals' genetic potential because of unfavorable environmental conditions, insufficient technical support and inadequate feeding practices (33). Consequently, the expected improvements in milk yield have been only marginal and productivity has remained well below anticipated levels.

A Pricing System that does not Incentivize Farm-level Investment: Securing a profit margin for producers that reflects actual production costs can only be achieved through real involvement of farmers in political decision-making processes and by strengthening producer organization.

This calls for fair and continuous negotiations over farm-gate prices. Without such mechanisms, dairy producers may abandon their activity due to

unbearable economic losses. This goal requires a spirit of cooperation and solidarity, through representative professional organizations that bring together all actors around shared interests.

Moreover, in our view, it would be beneficial to implement a selective approach to public support allocation, whereby aid is granted based on clearly defined performance criteria.

Conclusion

Since the implementation of the Agricultural Development Program in 2001, peri-urban dairy cattle farming has experienced significant growth, driven by the increasing demand from the city of Algiers for dairy products such as cheese, camembert, fresh milk, curd and others. A variety of dairy farming systems have emerged, ranging from small family-run farms with minimal investment to relatively large operations with 30 to 70 dairy cows, all functioning within a rapidly expanding dairy industry.

However, the average recorded milk yield remains low, at just 17 liters per dairy cow per day. The modernization of dairy farming towards intensive systems has not materialized, largely due to the low investment rate, which is estimated at only 2.98%. Another critical factor contributing to the inefficiency of the sector is the high production cost, which must be rigorously monitored, as is done in other major dairy-producing countries.

The present study confirms the increasing financial difficulties faced by dairy farmers in Algiers. As a result, 70% of them have expressed their intention to abandon dairy farming if the situation persists, reflecting a strategic choice to limit on-farm investment due to both internal and external constraints. Variable costs account for approximately 83% of the total production cost, with feed expenses alone comprising 57%, severely hampering the economic efficiency of current production systems.

The cost of milk production ranges between €0.49 and €0.78 per cow per day, which, in many cases, exceeds the farm-gate milk price, highlighting a deficit in the profitability of these operations. Farmers increasingly rely on diversification strategies including meat production and the sale of by-products such as calves and heifers to improve cash flow. However, for many of them, the economic viability of the dairy unit is under threat

and they struggle to maintain purchasing power and a steadily declining minimum profit margin.

Policy and Strategic Recommendations

To support the development of peri-urban dairy farming in Algiers, efforts should be focused on reducing key costs, especially those related to feed and labor, which are the most decisive factors for farm profitability. Producers must adopt new technologies and smart farming solutions to enable more efficient farm management. The use of digital tools and automation is now essential for tracking and controlling production costs and for making more informed strategic decisions.

Indeed, the introduction of technical progress including mechanization, digitalization, improved animal husbandry practices and animal welfare could yield significant economies of scale and help foster the growth of peri-urban agriculture. Additionally, efforts should be made to preserve arable land, improve the business environment and provide targeted public support through incentive-based public policies (e.g., access to credit, input availability, market organization, training and extension services).

In this context, we recommend the implementation of good dairy farming practice standards, accompanied by stricter supervision of farmers by local agricultural development institutions. Moreover, enhancing the premium payment system, including quality-based incentives and opening credit lines for investors looking to establish modern farms at attractive interest rates with maximum facilitation would be beneficial. A selective approach to public aid allocation should also be introduced, based on specific performance criteria.

Furthermore, embracing sustainable development in response to climate change and biodiversity preservation is increasingly important for the region's farmers. Promoting the repopulation of farms with locally selected dairy cows is recommended. Developing a milk dehydration industry along the coastal region could provide stable market outlets, serving as a regulatory tool for the dairy sector and a form of risk management for producers.

These goals cannot be achieved without the qualitative strengthening of the human capacity within public institutions responsible for accompanying these changes. Sectoral authorities are therefore urged to act on three critical levers:

pricing, institutional frameworks and technological progress.

Despite the valuable insights provided by this study, certain limitations should be acknowledged. The main limitation was the rapid urbanization of the peri-urban study area, which restricted the scope of the sample, as livestock production units are continuously undergoing spatial and land-use changes. This dynamic context limited access to a broader and more stable sample of farms. Future research should therefore consider longitudinal studies with larger and regularly updated samples to better capture the temporal evolution of peri-urban livestock systems. In addition, further investigations could examine the long-term effects of urban expansion on livestock farming sustainability, land-use dynamics and farmers' adaptation strategies.

Abbreviations

Cp: Cost of Production, DA/L: Algerian Dinars per Liter, Euros/Dairy Cow/Day: Euros per Dairy Cow per Day, L/VL/JR: Liters of Milk per Cow per Day, RDTVL: Milk Yield per Dairy Cow.

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Author Contributions

Karima Kouachi: Conceptualization, Study Design, Study Coordination, Data Collection, Statistical Analyses, Writing – Original Draft, Bahia Bouchafaa Hammadou: Conceptualization, Study Design, Study Coordination, Statistical Analyses, Writing – Original Draft, Ahcene Kaci: Conceptualization, Study Design, Study Coordination, Writing – Original Draft, Mounir Ghezal: Conceptualization, Study Design, Study Coordination, Data Collection, Statistical Analyses, Writing – Original Draft, Houria Hadjloune: Data Collection, Hafidh Zemour: Statistical Analyses, Fathi Abdellatif Belhouadjeb: Writing – Original Draft. All the authors revised all versions of the manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest associated with this study.

Data Availability

Following the survey we conducted, a database has been established, enabling us to respond in real time to all related requests. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that no generative AI or AI-assisted technologies were used in the writing, analysis, interpretation, or preparation of the scientific content of this manuscript. However, an AI-assisted tool was used solely to improve the visual quality and resolution of the figure 1. The design, data, scientific interpretation and original work presented in the figure were entirely developed by the authors. The authors take full responsibility for the content's originality, interpretation and accuracy.

Ethics Approval

This study involved a voluntary survey of livestock farmers. All participants were informed of the study's objectives and provided verbal consent. No sensitive personal data were collected.

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