Economic analysis of different dairy production systems in Ghana and Senegal: an application of typical farm approach[1]

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Summary

Ghana has been experiencing a significant increase in the demand for dairy products due to rising incomes, population growth, urbanization, and changes in dietary choices. However, due to the low domestic milk production capacity, Ghana relies heavily on imports to meet local demand. This study aimed to identify and characterize prevailing dairy production systems in Ghana; and measure and compare their costs and returns using the TIPI-CAL model (Technology Impact, Policy Impact Calculation model). Three typical farms were selected from each production system: confined-cut and carry (GH-03), agro-pastoral (GH-35), and pastoral production systems (GH-27). The cost of milk production for GH-03, GH-35, and GH-27 was €58.48/100kg Energy Corrected Milk (ECM), €49.05/100kg ECM, and €39.51/100kg ECM, respectively. All three farms had a positive entrepreneur's profit and covered their full economic cost from dairying in the short, medium, and long terms. However, the GH-27 was economically unviable in the long term for finished cattle because of the high opportunity cost of labor. Nonetheless, the market had a low absorption capacity for surplus milk mainly due to the lack of infrastructure and cooling facilities. Other issues such as low milk yield, shortage of forage, lack of artificial insemination, and the lack of organized marketing facilities were the major constraints faced by dairy farmers in Ghana.

Keywords: Dairy production systems, Typical farm approach, Economics, Ghana.
JEL: Q12, Q13, Q18

1 Introduction

Livestock plays a crucial economic, social, and cultural role in determining rural well-being and poverty alleviation in Ghana. Livestock provides a viable subsidiary occupation for a large proportion of the population and animal protein for human nutrition, particularly among the poor in the rural areas (MoFA/DFID, 2002). It serves as a bank and insurance in times of hardship to solve emergency financial needs such as purchasing food and agricultural inputs, settling medical bills, paying school fees, expenses for funerals, paying dowry at marriage, etc. (MoFA/DFID, 2002). Also, draught bullocks and cow dung, more specifically in the northern regions, enable farmers to cultivate 60% more land than farmers who do not have bullocks. In Ghana, nearly 74% of the agricultural households are engaged in animal husbandry alongside crop farming (MoFA, 2016). Policymakers and stakeholders have therefore identified livestock production as a critical policy option to improve rural incomes and poverty alleviation (FAO,2012).

Cattle farming is concentrated mainly in the Northern, Upper East, and Upper West regions of the country, where about 75% of the cattle population is distributed (DAI, 2014). The cattle population amounted to about 1.8 million heads in 2016 (SRID and Veterinary Directorate, MoFA, 2017). Cattle are typically kept for beef production by indigenous farmers and Fulani herdsmen, which accounts for nearly 33% of all domestic meat production (Osei, 2018). Dairy farming is relatively new and under-developed without adequate attention given to the industry. As a result, much of the milk and milk products consumed locally are imported. More than 90% of the local milk production comes from agropastoral production systems with low productivity of about 0.4 and 0.8

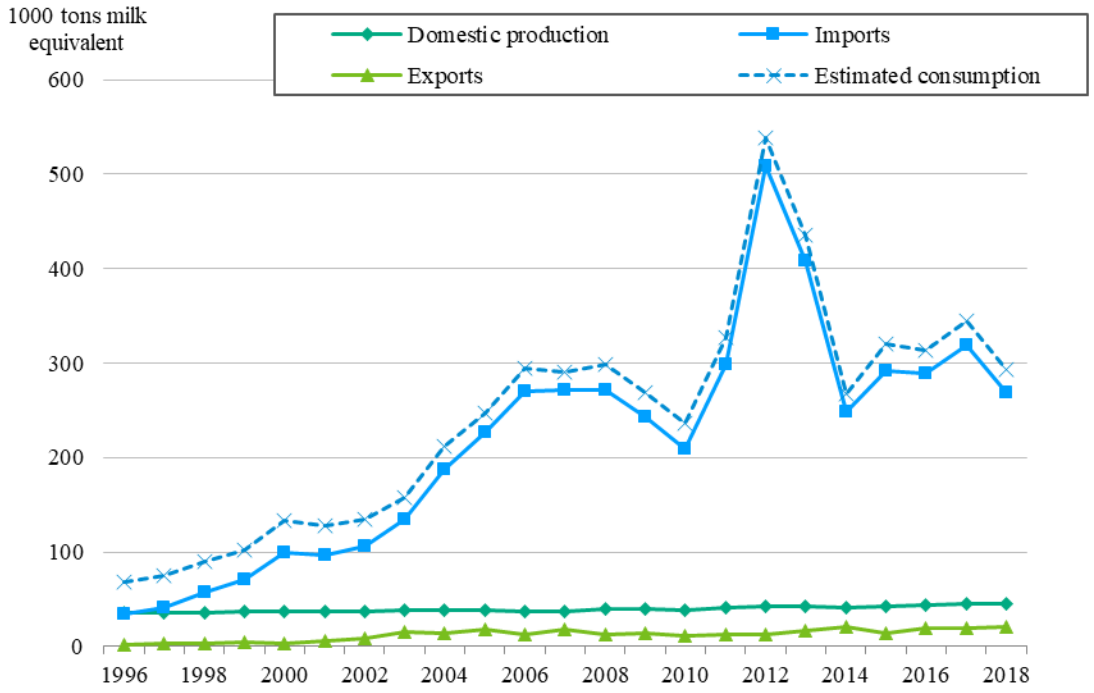
kg per cow per day in the dry and wet seasons, respectively (Oppong-Anane, 2008). Sanga and the West African Short Horn (WASH) are the predominant dairy breeds in Ghana, and a few cattle owners also use Friesian - Sanga crossbreds or Jersey cows (Oppong-Apane, 2016).

The Fulani herders are originally pastoral and nomadic people who form an integral part of Ghanaian society, and their main occupation is the herding of cattle. Around the twentieth century, Fulani pastoralists started migrating to Ghana due to three primary reasons. First, the thriving expansion of the cattle trade; second, the establishment and development of native administration farms; thirdly, the Sahelian drought of the 1970s and 1980s forced them to search for pasture and water for their cattle (Tonah, 2005:21). Although the Fulani's have been living in Ghana for more than a century, they most do not have the right to claim ownership of the land and natural resources (Bah, 1983; Bukari & Schareika, 2015). In this regard, the rights of the Fulani herders are limited. Notwithstanding these limitations, the Fulanis are still herding cattle as their primary occupation in the country. The rearing of cattle by the Fulanis is commonly separated in terms of cattle ownership and cattle management. The owners usually buy and sell the cattle, while the Fulanis are in charge of milking and often receive milk as compensation or salary (Oppong-Apane, 2016).

The local demand for milk and dairy products in Ghana is growing due to the rapid population growth, urbanization, diet change, and the growth in per capita consumption. Despite being one of the lowest in the world, the per capita consumption of dairy products in Ghana has risen from 3.9kg in 1996 to 9.9kg of milk equivalent in 2018 (FAO, 2013; UN Comtrade, 2018). Local milk production, however, was almost stable

over the same period and has been unable to keep pace with the growing demand for milk and value-added dairy products (such as cheese, butter, ice cream, yoghurt, and other milk beverages) (Figure 1). This is the reason behind the continuous heavy reliance on imports to satisfy the increasing local demand for dairy products. Therefore, increasing local milk production, provision of infrastructure, and encouraging local consumption of fresh milk would be an excellent solution to the greater reliance on dairy imports.

Figure 1: Development of the Dairy Sector in Ghana from 1996 to 2018 (in 1000 tons, milk equivalent)



Note: The domestic consumption is estimated based on imports + production - exports. Storage was not considered.
Source: Zamani et al., 2021.

Due to great concern about milk quality and safety and the unhygienic practices of informal milk marketing agents, Ghana's dairy industry is challenging the low demand for local milk and its products, which is mostly attributed to low milk quality and safety

standards (Karikari et al., 1998; Donkor et al., 2007; Kunadu eta al., 2019). Milking is usually done in the Kraal, and around 98% of the farmers do not tie the cow's hind legs leading to contamination of milk from soil, dirt, and manure (Gidiglo, 2014). Therefore, most Ghanaians prefer to buy imported milk or milk powder because they believe it is safe compared to locally produced milk (Karikari et al., 1998). At the farm level, Ghana's milk producers are facing many challenges, such as predominance of indigenous low milk yielding cattle, poor farm management practices, lack of formal training in Milk handling, and absence of financial resources to purchase cattle feed (Gidiglo, 2014). These challenges have resulted in highly fragmented industry, which dominated by traditional practices, making the business less attractive to investors.

Due resources availability, mainly land and feed, dairy production systems in Ghana have the potential for performance and economic development to better meet the growing demand in domestic market. Research on the different dairy production systems and economic indicators of different milk production systems at the farm level in Ghana was limited. Also, to the best of our knowledge, no previous work had addressed economics of dairy farming systems in Ghana. Thus, the main purpose of this study is to analyze and compare the economic indicators of production costs and profitability of different dairy cattle production systems in key production regions in Ghana. For this purpose, the study harnesses the typical farm approach to identify and characterize the prevailing dairy farming systems in the country and compare the economic indicators of in Ghana. Therefore, this study contributes to the literature on empirical analysis by examining production costs, inputs productivity, and farm profitability of the identified dairy cattle production systems in Ghana. These analyses will be helpful to understand the production

system-specific characteristics and management practices that could hamper the development of dairy production in Ghana. Such understanding could be helpful for dairy producers and agribusiness to formulate advanced management interventions for more productive and stable dairy production in Ghana.

2 Data and method: the typical farm approach (TFA)

The concept of ‘typical farms’ or ‘representative farms’ was initially proposed by Elliot in 1928 (Elliot,1928). Since then, many researchers have applied this concept in agricultural research (Dillon and Skold, 1992; Ndambi,2008; Uddin et al., 2010; Alqaisi et al., 2014; Kress and Verhaagh, 2019; Chará et al., 2019; Lasner et al., 2020; Chibanda et. Al 2022). The Typical farm approach (TFA) is a method used to collect farm data, construct typical farms and validate typical farm data. This approach has a strong scientific foundation because of its capability to produce results that are closer to reality

than the statistical averages with limited resources (Ndambi and Hemme, 2009; Hemme et al., 2004; Uddin et al., 2012; Hagemann et al., 2011).

The TFA has been widely applied in economic analysis of dairy production by various institutions and published researches. For example, the approach is implemented by the International Farm Comparison Network (IFCN) to compare the economics of different dairy farming systems worldwide. Uddin et al., (2010) have applied the TFA to compare milk production costs in different typical dairy production systems in Bangladesh. Ndambi and Hemme (2009) compared the costs and returns of typical dairy farming systems in South Africa, Morocco, Uganda, and Cameroon through the application of TFA. In addition, the TFA has been used by Hemme et al. (2014) who benchmarked milk production costs in 46 countries to select 104 dairy farms from 46 countries and 52 dairy regions. Sultana et al. (2014) also applied the TFA to select 157 typical farms from 48 countries to analyze disaggregated water use in different milk production systems. A recent study by Uddin et al. (2020) estimated economic loss due to Coronavirus (COVID-19) in two typical dairy farms in Bangladesh.

For the purpose of defining typical farms, a Standard Operating Procedure (SOP) was used to ensure that all participating countries used the same approach and working steps. In this study, the TFA was employed as founded by Agri benchmark SOP, which was outlined by Chibanda et al. (2020). The SOP consists of six basic steps:

Step 1: Identifying the most significant regions and prevailing production systems

The most important dairy regions in terms of milk production (highest total population of cows per region) were identified by investigating existing national and regional statistics in combination with the consultation of local experts. Parts of Greater Accra such as

Agbogba, Areas in the Accra Plains such as Kpone, and the northern parts of Ghana (eg. Tamale environs) were identified as the most significant regions in terms of dairy production in Ghana. The areas were selected because a significant number of dairy farms were located there, and also contributes a significant amount of milk to the local milk supply.

Three dairy production systems were identified in close collaboration with local dairy experts based on the farm size, feed ration, labor utilization, and management levels. These dairy production systems include confined-cut and carry, agro-pastoral, and pastoral production systems. A multi-stakeholder workshop was then held in Accra (Ghana) on 6 September 2019 to thoroughly discuss the characteristics of typical dairy production systems, the value chain, key challenges and opportunities, including the competition with imported milk powder. A total of 44 participants attended the workshop representing farmers, processors, researchers, and policymakers. Participants were divided into small groups of 8 experts, where the characteristics of each production system were verified including the predominant production systems in the region. Moreover, the characteristics of the typical dairy production systems were further verified and validated through consultation with local researchers of the Council for Scientific and Industrial Research (CSIR).

Step 2: Selection of farms within the prevailing production system

After the identification of the most significant milk production areas and the production systems, one farm for each identified production system was selected with the help of existing national and regional technical documents and local experts. Therefore, three

individual dairy farms were selected to represent the three dairy production systems in Ghana.

Step 3: Farm visits and interviews

Data were collected from the selected individual farms through face-to-face interviews of dairy farmers between February and March 2020. A standard questionnaire was used to collect the detailed farm data. Each respondent was given a brief description of the nature and purpose of the study. The interviews lasted between two and three hours. The data collected related to the land endowment and barn use patterns; production, inputs, costs, and profits/income from dairy farming; assets; family and hired labor usage, and herd management.

Step 4: Focus group discussions

Focus groups are the core element of TFA (Lasner, 2020; Siqueira and Duru, 2016). After collecting the data from the individual dairy farms, a focus group discussion was organized with farmers and local experts to typify the individual farm data. The focus group discussion was conducted the following day of each farm visit of the particular production system. A total of three focus group discussions were held, one for each identified production system. Each focus group discussion consisted of ten experts, comprising two local researchers, one extension officer, one veterinary officer, one agricultural officer, and five dairy producers. In all, thirty (30) participants were involved in the study. The focus groups were used to construct the typical farms. More specifically, the participants discussed each farm value (e.g., farm inputs, farm outputs costs, prices, lactation performance, and mortality) until they reached a consensus on

each figure to properly describe the typical situation within a production system and region.

Step 5: Data analysis

The collected typical farm data were analysed after validation by utilizing the Technology Impact Policy Impact Calculation model (TIPI-CAL) developed by Hemme (2000). This model was developed as a standard for farm economics to analyze physical and economic parameters of crop and livestock production systems. In this study, the TIPI-CAL model calculates the costs and returns per 100 Kg of milk produced by the typical farms representing the three most common production systems in Ghana. Some costs were directly collected on a per cow basis. However, costs collected on the whole farm level were allocated to the farm enterprises analyzed such as crop and feed production (in the case of on-farm feed production) and dairy production. Whole-farm level costs include equipment and buildings, land, labor, and overhead costs. These costs are allocated to the analysed farm enterprises based on their share in total farm revenues. Regarding returns of dairy production, the model considers milk, calf, cull animal and finished cattle returns.

Costs calculation

The total cost component is classified into three major categories as follows, according to the *agri benchmark* approach (Deblitz, 2013). (1) Cash costs, comprising the cost of animal purchases, purchased feed, crop production costs (fertilizer, seed, pesticide), land or leaseholds, wages of hired labor, maintenance costs (cow barns, feeding and milking equipment), veterinary services (vaccination and drugs), electricity, water charges. (2) Depreciation costs account for the decline in the value of buildings, machinery, and other

assets over time. This study took replacement cost is an amount that it would cost to replace an asset of a farm at the same or equal value. (3) Opportunity costs, quantifying the value of farm-owned factors of production such as family labor, own land area, and own capital. Total cost also can be also expressed by factor and non-factor costs. Factor costs are composed of both cash and opportunity costs of land, labor and capital. While non-factor costs cover all other costs including depreciations.

Returns calculation

Regarding returns of dairy production, TIPI-CAL considers milk, non-milk returns (i.e., cull animals, weaned calves, surplus heifers and finished cattle returns) and subsidies. The milk output per farm is adjusted to ECM[2] (Energy Corrected Milk), with 4% fat and 3.3% protein. The TIPI-CAL model calculated the *short-, medium- and long-term profitability per* 100kg milk ECM. The short-term profitability of producing 100kg milk ECM was measured by subtracting cash costs from total returns, while medium-term profitability was obtained by subtracting cash and depreciation costs. A dairy farm can be long-term profitable if total returns cover total costs (cash, depreciation, and opportunity costs).

Step 6: Data validation

Results obtained from the farm economic analysis were shared with local experts to verify the validity of the findings. This step would ensure that the results align with the reality of typical dairy farms in the selected production systems and regions.

[2] Energy Corrected Milk (ECM) expresses the amount of energy in the milk based upon milk, fat, and protein and is adjusted to 4.0 percent fat and 3.3 percent protein. This standardization allows us to compare the farms' efficiency and profitability accurately and improves decision-making over time.

3 Results and discussion

3.1 Typical production systems in Ghana

Dairy production in Ghana is broadly classified into three production systems which include the confined-cut and carry, agro-pastoral, and pastoral production systems. The key characteristics of production systems are summarized in Table 1.

Table 1. Characteristics of typical dairy production systems in Ghana

Production systems	Confined-cut and carry	Agro-pastoral	Pastoral
Location	Urban areas	Peri-urban	Rural
Purpose of cattle	Solely dairy	Beef and dairy	Beef
Breeds	Exotic/cross breeds	Local, cross breeds	Local
Feed type	Zero-grazing Crop residues such as baled rice straw, cassava peels	Semi-grazing ranching	Extensive grazing
Milk use	Selling on the market	Selling on the market	Consumption by herdsmen and calf, surplus sold on the market
Land use	Zero grazing, land space for housing and confinement	Land space for crop and production, grazing	Mainly grazing, other agricultural production such as crops
Labor use	Family labor	Cattle owner and Fulani	Fulani

The dairy confined-cut and carry system employs complete housing with zero-grazing and is mainly practiced by institutional farms and about 100 households, with few cattle in their backyards in the Eastern and Greater Accra regions of Ghana, usually around the urban areas (Oppong-Apane, 2016)**.** This system comprises a few backyard farms which typically have three cows, three calves, and occasionally a bull. The agro-pastoral dairy production system usually provides housing and feed supplements with other feed sources such as crop residues and grazing. The pastoral production system is the dominant system practiced by smallholder farmers where grazing is done extensively on a free-range. The cattle are housed in Kraals and not fenced or in a simple structure constructed from local materials such as tree branches and bamboo. Ownership in this system can be direct (single-owner) or trusteeship for the family. In cases where the herd is large, several family groups may share the ownership. This system is mainly focused on meat production, with little attention to milk, where the milk produced is usually shared between the herdsman and the calf, and the surplus sold on the market (Oppong-Apane, 2016).

3.2 Characteristics of typical dairy farms

Three typical dairy farms representing the identified production systems were constructed. They are GH-3, GH-35, and GH-27 representing confined-cut and carry, agro-pastoral, and extensive production systems, respectively. A detailed description of the selected typical farms is depicted in Table 2.

Table 2. Description of typical dairy farms

Typical farm	GH-03	GH-35	GH-27
Farming system	Confined-cut and carry	Agro-pastoral	Pastoral
Location	Agbogba region	Tema region	Tamale region
Land owned (ha)	0.20	0.40	1.60
Grazing area	No	Yes	Yes
Dairy Enterprise			
Milking animals (no.)	3	35	27
Breeding bulls (no.)	1	1-2	3
Breed	Jersey breed, Friesian x Sanga crossbred, local breeds	Jersey x local crossbred, local breeds	Sanga breeds
Sale weight of cull cows (kg Live weight)	400	300	200
Milk yield (kg ECM/cow/year)	4160	1062	962
Land use			
Stoking rate (cows/ha)	15	87	17
Labor usage			
Permanent labor (no.)	0	1	0
Hours/permanent labor/year	0	2912	0
Family labor (no.)	3	1	7
Hours/family labor/year	1008	1680	2080
Buildings			
Housing type	Two unsophisticated cow barns	Cattle kraal	Cattle kraal
Milking			
Equipment used	Gallon bottles, freezer	Gallon bottles, wheelbarrow, shovel, solar lamp	Gallon bottles
Main breeding objective	Milk	Beef	Beef
Herd management			
Age at first calving (months)	22	36	36
Dry period (months)	2	2	2
Feed ration			
Dry season (kg/cow/year)	1.4 wheat bran 3.6 cassava peels 5.7 brewers' grain	7.5 wheat bran 1.0 cassava peels salt	1.2 cow-pea 0.8 cassava peel
Wet season (kg/cow/year)	12 grass and plantain leaves	Salt and minerals	Grazing
Calf rearing			
Calves born alive (no./cows/year)	0.67	0.80	0.67
Weaning period (months)	3	10	7

GH-03

GH-03 represents a typical confined-cut and carry dairy farm located around urban centers like the Agbogba area in the northwest part of the Greater Accra Region. The farm is small, and the farmer keeps three milking cows and one bull, mainly Jersey breed, Friesian-Sanga crossbred, and local breeds. The land size was 0.2 ha without separate pasture land for grazing. The farm includes two unsophisticated cow barns and the farmer's house. The cows are kept under a zero grazing system and feed with purchased feed concentrates such as wheat bran, cassava peels, and brewers' grain for six months of the dry season. However, in the wet season, purchased grass and plantain leaves are used for feeding. In this system, the farm tasks are carried out almost entirely by three family labor, working in total 10 hours per day. Milk production under this system is about 13 liters per day per cow, and milking is done manually with the hand. Usually, the milk is collected into plastic gallon bottles and stored in the freezer for preservation. The farm family consumes about 3 liters of the milk produced on the farm, the surplus (77 percent) is being sold at 0.66 euro per liter. Compared to the other two production systems where cattle finishing is the main source of income, milk production is of highest interest in the GH-03 farm. Thus, calves are sold directly after weaning.

The field survey in this system shows that the age at first calving was 22 months, and with the tendency of a cow giving birth to a calf every 18 months. Cows are slaughtered, on average, at 12 years of age (after 8 calvings) with an average weight of 400kg. A heifer calf is either sold after weaning or kept as replacement stock. Male calves can either be used as a breeding bull or sold after weaning. The cow and calf mortality rates

were reported as 0.25% per year. This system has a strong market orientation and more emphasis on feeding and breeding management to assure optimal production.

GH-27

This typical farming system is usually employed in the rural areas of Ghana such as in the Tamale environs situated 600km north of Accra. It is a pastoral system that keeps about 27 milking cows and three bulls. These include cross-bred cows from the West African shorthorn (WASH) and the white Fulani called Sanga. The Sanga cattle breed is well adapted to the arid weather conditions of northern Ghana. On this typical farm, cows are kept as a form of insurance and means of savings to provide financial support in times of need. The cattle owner is not necessarily to be a farmer, but in most cases, he has another off-farm business and is not engaged in any of on-farm activities. The main responsibility of the cattle owner is to decide on selling animals (cull cows, heifers and bulls). A Fulani herder is employed with the responsibility for the herd management. A Fulani family of 15 members is living in this farm. Of which, only seven members are working for the cattle every day for the whole day and get the total milk produced plus 60.35 euro per year for medical care expenses and maintain the mud hut. The Fulani men are responsible for cattle management and milking while the women are responsible for selling the milk and processing of wagashi (local cheese), particularly during the wet season.

The farm operates on 1.6 ha land, of which 75% is used for maize cultivation and 25% for the cattle kraal and the Fulani house. Fulani generally grows maize as a food crop for household consumption, and after harvest, cattle are grazed on residues. Cows also graze on pasture throughout the year under the district assembly control -especially in the dry

season when pastures are limited. Only lactating cows are provided with little feed supplements like cow-pea and cassava peel during the dry seasons.

The average daily milk production per cow was 4.0 liters and 0.8 liters in the wet and dry seasons, respectively. The farm gate milk price is determined by buyers based on farm distance to the nearest market. The average farm gate milk price was 0.30 euro per liter. Processed wagashi was sold at 0.24 euro per block. Milk is an essential component of a Fulani's diet, and as a result, the farm family consumes about 12.0 liters of milk every day. A similar situation was studied in Uganda (Ndambi et al., 2008), Kenya (Muriuki et al., 2001), and Cameroon (Boutrais, 2002; Ndambi and Hemme, 2009).

On this farm, the age at first calving was 36 months, and cows give birth to a calf every 18 months. Cows are slaughtered, based on health status, after 10-15 years with an average weight 200kg per head. More interestingly, there is no systematic approach to selling cows in this farming system because the cattle serve as a saving instrument. They sell heifers just in case if someone needs heifers to start a new farm business. In most cases, heifers are sold at the age above three years old. Otherwise, the cattle owner prefers to sell the old cows or young bulls rather than heifers whenever the he needs some cash. Male calves are kept on the farm up to 3-4 years of age to be sold as finished cattle at age of 3-4 years and 325 kg live weight. The cow and calf mortality rates recorded at 0.37% and 2.0% per year, respectively.

GH-35

This typical farm is located in peri-urban areas like the Kpone in the Greater Accra Region. On this typical farm, 35 milking cows and one bull are kept. The estimated land size of this farm is 0.4 ha, including the cattle kraal and the home of the Fulani family

that rears the cattle. The breeds of cows on this farm include the cross-bred cows from the Jersey breed, the Nigerian, and the local breeds. During the wet season which usually last about six months, cattle are allowed to graze in the open grassy fields under the control of the district/municipal assemblies. In addition to grazing, a low amount of concentrates such as wheat bran, cassava peels, salt, and minerals are used to supplement feeding in the dry season. Year-round labor to operate this farm is supplied by one family member who works maximum five hours/day and one permanent employee who works 10 hours per day during the dry season and 8 hours per day during the wet season. The permanent labor is fully engaged in the daily farm activities such as cattle feeding and milking.

In a GH-35 farming system, the average milk production per cow per day was 3.0 liters in the wet season and 1.5 liters in the dry season. Milking is commonly done in the kraal and collected into plastic containers. The farm family consumes about 4.0 liters of milk per day, the surplus is being sold at the farm gate at 0.81 euro per liter. When there is no market for the surplus milk, it is processed into dairy products such as wagashi. It was estimated that about 40% of the milk produced per day is processed into wagashi. Usually, the surplus milk is recorded in the wet season during which there is abundance of forage and water. In the GH-35, the farm gate milk price is higher compared to the GH-03 because of the high demand from the dairy processors and some Indian expatriates who prefer the consumption of fresh milk.

In this farming system, the age at first calving is 36 months, and the cows tend to give birth yearly. Cows are slaughtered, on average, after 9-10 years with an average weight of 300kg. Unlike the GH-03 farm, heifers in this system are not slaughtered for meat

before the age of three years. The high price was attributed to the fact the heifers were in their prime age of productivity. For the purpose of meat, majority of male calves are castrated and raised for about 4 years before being sold. Notwithstanding, the cow and calf mortality rates in this farming system were reported as 0.25% and 1.0% per year, respectively.

3.3 Cost of production

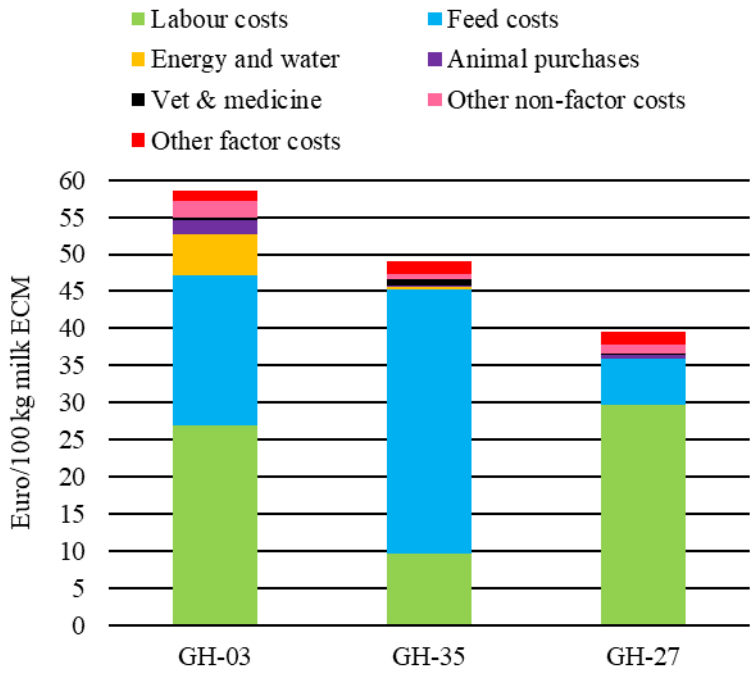


Figure 2: Comparison of milk production costs (whole farm level)

Figures 2 represents the total cost structure in the selected typical farms in Ghana, based on 100kg milk ECM. In case of GH-35 and GH-27, the presented cost structure covers both dairy and finished cattle production (whole farm level). However, CH-03 has no finished cattle costs as calves are sold directly after weaning. GH-03 has the highest milk production cost at €58.48 per 100kg ECM, whereas the GH-27 has the lowest at €39.51.

Labor costs represent 75% of the total production costs for GH-27, 46% for GH-03, and 20% for GH-35. GH-27 has the highest labor cost as Fulani family get the total milk produced. This corroborates studies by Ndambi (2008) and Olupot and Sseruwo (2004) who reported extremely high labor input for intensive dairy farms in Uganda. The relatively high labor cost in GH-03 is mainly attributed to the opportunity cost of family labor.

GH-03 farm entirely relies on purchased feed supplements during the dry season and also purchase grass and plantain leaves during the wet season. However, GH-35 usually provides purchased feeds only during the dry season to help maintain milk production. Nevertheless, feed costs account for 35% of total costs in the GH-03 and 73% in the GH-35. High feed cost in GH-35 compared to GH-03 is due to i) the wide disparity in cow productivity between both farms and ii) the feed intake by heifers and bulls in GH-35, which are kept on the farm for an extended period compared to GH-03, which sell calves after weaning. Expectedly, the GH-27 farm had the lowest feed cost of €0.84 per 100kg ECM mainly because of year-round grazing. On the GH-03 farm, milk production is the focus where cows are milked twice a day and stored in the freezers. Thus, they have higher energy costs of 9% of the total cost.

GH-35 and GH-27 farms do not sell calves after weaning but they keep them on the farm as cattle on feed to be sold for slaughter at age of 3-4 years. To better understand how the cost structure will be changed if the farms could specialize in dairy production by selling calves after weaning, we modified the TIPI-CAL model to split both farms into two enterprises; dairy and finished cattle. During the field visit, we asked the GH-35 and GH-27 farmers about feed, labour and veterinary inputs allocated to weaned cattle until

reaching the slaughter age. Furthermore, we asked the farmers how much they would get for selling their calves after weaning to be finished in another farm. Figure 3, therefore, shows the cost structure of milk production only. Total cost of milk production for GH-35 and GH-27 was €18.90/100kg ECM and €27.76/100kg ECM, which is 61% and 45% lower than the whole farm level cost, respectively. Feed costs account for 54% of total costs in the GH-35 and 7% in the GH-27. This means, compared to the whole farm level (milk and finished cattle activities), feed costs have diminished by 71% in the GH-35 and 74% in the GH-27% if the farmers focus only on milk production and sell calves after weaning.

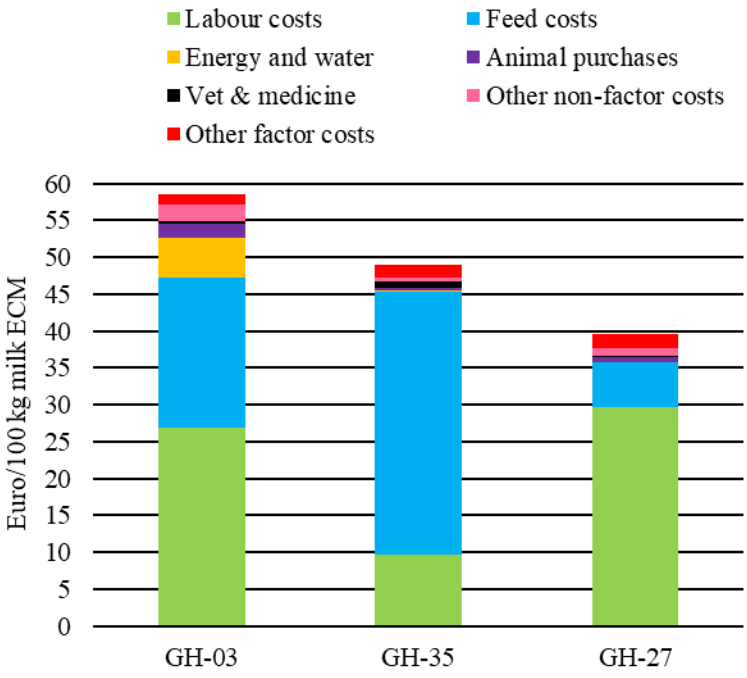


Figure 3: Comparison of milk production costs (dairy enterprise only)

3.4 The profitability of dairy farms

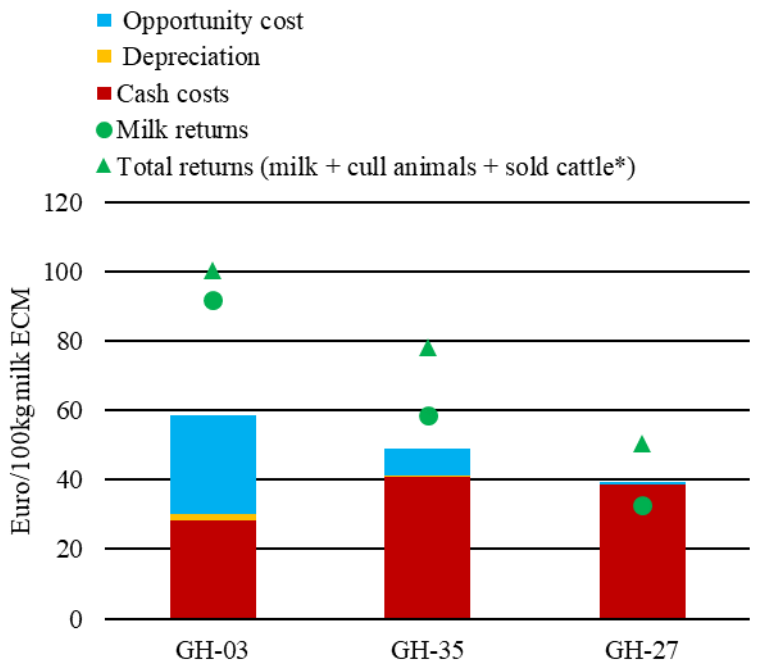


Figure 3: Profitability of the typical dairy farms (whole farm level)
Note: Calves sold after weaning for GH-03, and finished cattle for GH-35 and GH-27

This study showed that GH-03 makes a high return of 91% of total returns from milk followed by GH-35 (75%) and GH-27 (65%). The differences in the results can be attributed to the better genetic potential of milking cows, intensive care, and access to a better milk price that enabled GH-03 farmers to get higher milk returns. However, GH-35 and GH-27 earned considerable returns of 25% and 34% from finished cattle, respectively. The study confirmed that all the farms analyzed were profitable in the short, medium, and long terms. Nonetheless, due to low productivity and low milk prices, milk returns in GH-27 are not able to cover cash costs.

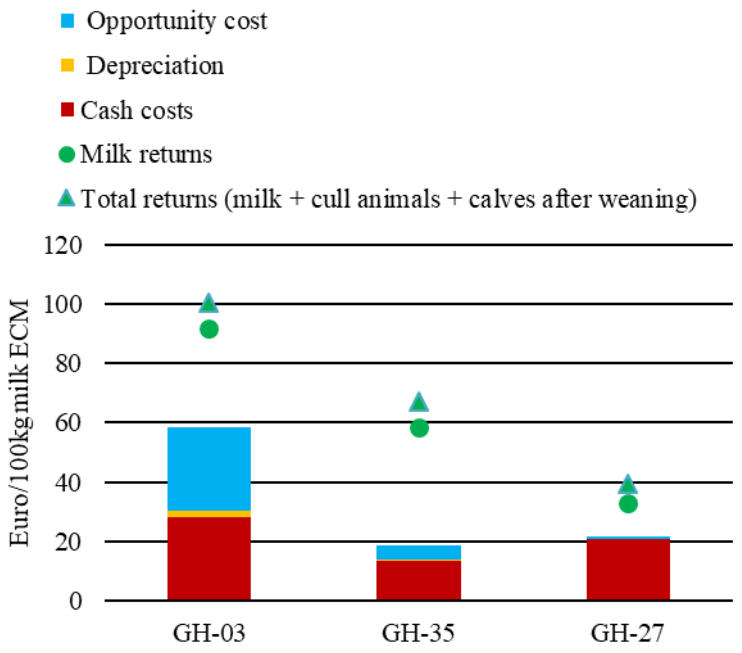


Figure 4: Profitability of the typical dairy farms (dairy enterprise only)

Considering returns and costs of the dairy enterprise only for GH-35 and GH-27, Figure 4 revealed that all the farms cover the total production costs and generate a positive net income. Despite the low milk price in GH-27, the farm became profitable in the short term as milk returns cover the cash costs when excluding the costs allocated for cattle finishing. Similarly, GH-35 could get better profit margin from milk returns when the farm business is limited to milk and calves production. These results thus imply that cattle finishing could hamper the economic efficiency in of both GH-35 (agro-pastoral) and GH-27 (pastoral). Therefore, both systems should focus most on milk production by selling surplus *calves* after weaning.

The typical farm-gate milk price in the study ranged from €0.33 to €0.92 per liter. The farm gate milk price was determined by buyers based on farm distance to the nearest market. In our study, the GH-03 and GH-35 farms are located near urban areas and have

access to the milk market, therefore, receiving a higher milk price. Due to the long distance between the GH-27 farm and the milk collector, farmers milk their cows once a day. This was attributed to the lack of milk storage and processing facilities. Therefore, there is a need to develop a milk collecting network and infrastructure in the milk production areas.

The study further revealed various challenges and opportunities faced by smallholder dairy farmers in the different dairy production systems. The primary constraints were the insufficient production of fresh milk in the dry season due to low availability of forages. The introduction of improved forage varieties such as Napier grass (*Pennisetum purpureum*) (Mutimura, et al., 2018) and Brachiaria grasses (Adnew, et al., 2018), could compensate forage scarcity in dry season. Furthermore, the long distance to the milk collector, lack of storage facilities, lack of credit facilities, insufficient extension support, and poor road network limit the growth in the local milk market (Gunarathne and Biomah., 2022). The local cattle breeds used in the GH-35 and GH-27 farms, have a low genetic potential for milk yield which does not boost production. Moreover, farmers mostly depend on natural mating which is an old traditional method practiced by all farms. Therefore, artificial insemination and the use of higher-grade bulls have to be encouraged to produce cross breeds that will improve milk production. The study also revealed high calf and cow mortality in the GH-35 and GH-27 compared to GH-03 because of the susceptibility of the cows to risk during movement for grazing, such as snake bites, road accidents, etc.

Cattle in agro-pastoral and pastoral systems are often confined in an open or poorly roofed kraal where extreme weather conditions lead to poor health and lower

performance of cows. Milking is done manually in the kraal under unhygienic conditions without following standard farm protocols for milking. As a result, there is a high risk of microbial contamination of milk from mud, cow dung, urines, and flies (Donkor et al., 2007). The study showed that the farmers lacked cooling facilities for milk preservation and storage but rather used simple containers made from plastic, such as bottles, and jars (jerry-can) to collect and store milk. Therefore, milk is sold unprocessed directly after milking the cow or processed into wagashi, especially in the wet season.

Furthermore, almost all the local milk value chain actors lack formal training in milk handling and marketing skills. Thus, training and extension programs are needed to improve farmers' knowledge about milking and milk handling, storage, value addition, and marketing. Nevertheless, it was observed that there was a weak relationship between public institutions and farmers, and other value chain actors (Gunarathne and Biomah., 2022). Notwithstanding, there are vast opportunities that the milk industry can provide such as a regular source of income due to the high demand for fresh milk and wagashi (ready market), the vast market for dairy products, export and employment opportunities in Ghana.

4 Conclusion and recommendations

This study used the TIPI-CAL model to calculate and compare the milk production costs of three typical farms located in Agbogba, Tema and Tamale. Of which, each typical farm represents a particular milk production system in Ghana: confined-cut and carry (GH-03), agro-pastoral (GH-35) and pastoral (GH-27). The highest milk production cost was observed in GH-03 (€58.48/100kg ECM) due to higher input costs. In contrast, the lowest cost (€39.51/100kg ECM) was recorded in GH-27. The study further shows that

GH-03 has better returns compared to the other two typical farms. GH-03 and GH-35 have a positive profit on the long term as returns cover total production costs. However, due to low productivity, low milk prices and high costs of cattle finishing, milk returns in the pastoral system do not offset cash costs. Moreover, producers in GH-35 and GH-27 farms tend to focus on cattle keeping as means of savings rather than milk production. This, in turn, makes the agro-pastoral and pastoral production systems in Ghana inefficient in terms of the technical and economic indicators.

Furthermore, low milk yield, scarcity of forages, lack of storage and cooling facilities, lack of milk collection network, and lack of government intervention are major barriers to the development of the local milk industry in Ghana. It is recommended that government and the key stakeholders provide support to overcome these constraints in the industry to reduce cost and thus improve profitability.

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