DAIRY
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Acronyms

ANEB	National Association of Cattle Breeders (Association Nationale des Éleveurs de Bovins)
BSE	bovine spongiform encephalopathy
Cfu	colony-forming unit
EU	European Union
GDP	gross domestic product
ISO	International Organization for Standardization
MAAR	Ministry of Agriculture and Agrarian Reform
MAMF	Ministry of Agriculture and Marine Fisheries
TB	tuberculosis
UHT	ultra-high temperature
UNCAL	National Union of Agricultural Dairy Cooperatives (Union Nationale des Coopératives Agricoles Laitières)

US$1 = 9 Moroccan dirhams (March 2009)

Preface

Over the last five decades the global dairy sector has seen substantive changes with major intensification, scaling-up and efficiency of production driven by demand from a growing human population and disposal incomes. This growth was achievable through the developments in animal breeding, nutrition, feed efficiency, animal health, housing and automation and supporting policies, strategies and organizations. Such changes are not however reflected across the whole dairy sector and while some developing countries have seen a major expansion in small-scale milk production, small-scale dairying in other countries has largely stagnated.

Dairying contributes positively to human wellbeing in a variety of different ways: nutrition through quality food products, income and employment, organic fertilizer as well as assets and savings. There are however negative aspects associated with dairying including its contribution to Green House Gases, pollution and waste disposal, food safety and human health, use of grains for feed, animal welfare and erosion of biodiversity. In order to inform the public and to make rational policy and investment decisions related to the dairy sector, it is essential to fully understand these complex interactions and their consequences.

This paper provides a review of these issues for the dairy sector of Morocco. We hope this paper will provide accurate and useful information to its readers and any feedback is welcome by the author and the Livestock Production Systems Branch (AGAS)[1] or to the Rural Infrastructure and Agro-Industries Division (AGS)[2] of the Food and Agriculture Organization of the United Nations (FAO).

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Executive summary

Dairy cattle production has major social and economic roles in Morocco and similar countries. In Morocco, milk and calves are produced on about 790 000 farms, of which only about 5 percent can be considered specialized dairy farms. Cattle production occurs mainly on smallholder farms, where dual-purpose (milk and meat) systems dominate, often using local breeds or crosses with dairy cows (Holstein and Montbéliarde). In such situations, the average annual milk yield per cow is limited (at less than 2 500 kg), so calf production assumes a vital economic role. Annual milk output is closely linked to climate variations, and farmers often have to cope with serious droughts, which significantly alter their herds' economic profitability.

The impact of cattle production on Morocco's physical environment remains unclear, as there are very few studies of this. Acute problems linked to restricted water resources in many regions of the country have recently induced studies of water productivity from dairy cattle. The available results show that 1 500 litres of water is required to obtain 1 kg of milk, while a gain of 1 kg of cattle live-weight needs 7 000 litres.

Dairy cattle production provides farmers with a steady income, as the milk price is secure. The calf crop also constitutes a strategic income for when farmers face high expenses. Overall, the average annual gross margin per cow is US$180, including calf sales, for various cattle systems in Morocco. The dairy chain provides about 770 000 people with steady employment all year round, representing almost 10 percent of agricultural labour opportunities.

Raw milk safety in Morocco is generally low. In response to erratic hygiene on cattle farms and the resulting high microbial loads in raw milk, Moroccan legislation imposes the pasteurization of raw milk. Informal dairy chains may therefore constitute a hazard to consumers' safety. Average annual consumption of milk products is a relatively low 38 kg per capita, but varies considerably according to consumers' incomes.

Six kinds of dairy institution can be distinguished in Morocco: i) cattle farmers; ii) milk collection cooperatives; iii) milk collectors/pedlars in informal chains; iv) urban cafés and traditional milk shops (known locally as mahlabates); v) dairy industrial processors; and vi) various suppliers of services (veterinarian and insemination) and commodities (feed, machinery, etc.).

Currently, three kinds of dairy chain are active in Morocco. The first of these are the totally private chains that gather milk from farms and industrial dairy processors through milk collection cooperatives. Their activities are dominated by a single operator, the Centrale laitière, which handles almost 60 percent of the milk volumes processed by industrials and which has strong ties with the international dairy society Danone. This ensures that high-quality dairy derivatives are available on the Moroccan market. The second type of chain is based on cooperative processing, and has recently seen the emergence of a highly competitive cooperative called Copag, which handles some 20 percent of total milk volumes processed by industrials and is based in southern Morocco. The third kind of dairy chain relies on informal circuits, with milk processed into traditional products by small workshops and sold directly to consumers. These informal chains involve various numbers of operators and are active mainly in the dairy basins near large urban centres.

These characteristics of the Moroccan dairy chain mean that it faces important challenges as it upgrades itself in response to the demands of free trade agreements. One of the greatest challenges will be increasing the milk yield per cow on smallholder farms with limited means. Other concerns will be improving milk quality and ensuring fair remuneration in a context of fragmented supply. Questions related to the sharing of revenues among the chain's operators and to water productivity from dairy cattle farming will also be high priorities on stakeholders' agendas for the sustainable development of dairy production in Morocco.

Introduction

Located in western North Africa, Morocco is characterized by a mainly semi-arid climate and a rapidly growing human population, which increased from 15.3 to 30.4 million between 1975 and 2006. Faced with this demographic expansion and changing nutritional habits, in the early 1970s, the Moroccan authorities launched ambitious plans to satisfy the demand for food. Revised livestock policies sought to establish intensive cattle production, based on importing heifers of dairy breeds (Pie Noire, Montbéliarde and, more recently, Holstein) and extending forage areas. At the same time, State authorities implemented a milk collection policy.

These measures were supported by important subsidies on inputs (feed, cattle, forage seeds, etc.) and the protection of domestic dairy products through a 200 percent tax on imported goods. The overall aim was to create a dairy supply chain that could provide enough milk and dairy derivatives to satisfy the demands of a rapidly expanding population, giving priority to urban dwellers. At the beginning of the 1980s, however, a series of structural adjustment measures were implemented and subsidies were progressively suppressed. These changes had serious impacts on the organization in the dairy chain, by significantly modifying production practices. Another important development are the ongoing free trade negotiations with the European Union (EU), which may imply the end of all protection for local products.

This review assesses the current situation of the Moroccan dairy chain. It presents milk production systems and their recent evolution, describes trends in how dairy chain operators perceive environmental issues, and assesses the effects of dairying on livelihoods and employment opportunities in Morocco. The study also analyses Moroccan dairy products from the consumers' viewpoint, in terms of sanitary safety and contribution to protein supply. Finally, it describes Moroccan dairy institutions, both private and public, and the sharing of remuneration throughout the chain, from cattle farmers, through milk collection structures and processors, to retailers and consumers.

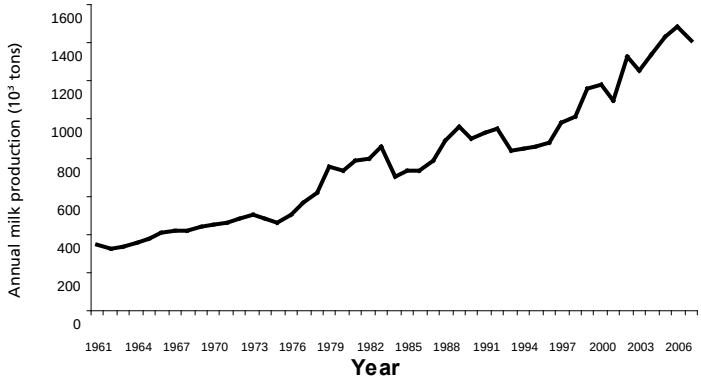
Chapter 1

Characterization of milk production systems

Milk and its derivatives have always been considered important but expensive components in the Moroccan diet, which is based mainly on cereals (bread) and vegetables. Milk has a strongly symbolic value in local traditions, as it is used with dates to welcome guests. Milk originates principally from cattle (2.7 million animals producing more than 96 percent of annual dairy output), with camelids and small ruminants producing a far smaller share. Until the period of colonization (1912 to 1956), milk was produced from local cattle breeds and marketed in short circuits from suburban farms directly to consumers. These herds were mostly beef-oriented, and had very limited dairy potential (of less than 1 000 kg, produced over no more than 200 days a year) (Projet Sebou, 1961). The presence of foreign settlers and the beginning of urban expansion were key elements in the emergence of dairy farms during the 1950s, with imported European cattle of high genetic value (mainly from France, such as the Pie Noire and Tarentaise breeds) (Vaysse, 1952). However, the need to produce sufficient milk volumes locally was not officially acknowledged until the 1970s, with the launching of the Dairy Plan (MAAR, 1975).

This dairy policy had significant consequences on the evolution of milk production (Figure 1).

FIGURE 1
Evolution of cattle milk production in Morocco (thousand tonnes)



Source: Ministry of Agriculture and Marine Fisheries (MAMF), 2008.

Given that the total number of cows has remained steady since 1970, the figures given in Figure 1 imply that the average milk yield per cow has been increasing, from 400 kg in the early 1970s to today's 1 000 kg. This significant improvement reflects the dairy intensification promoted by the agricultural policy (with its provision of feed concentrates, increased forage areas in irrigated zones, dairy cattle imports, etc.) rather than the aggregation of herds, as smallholder farms still constitute the vast majority (more than 80 percent) of production facilities. The agricultural policy has also affected the geographical spread of dairy activities, as the establishment of nine large-scale irrigation schemes led to a parallel concentration of specialized cattle farms; currently, some 55 percent of milk volumes come from irrigated areas, which represent less than 15 percent of agricultural land (Annex 1). In these irrigated regions, there has been a clear shift towards more dairy specialization, and more than 80 percent of the cattle are of improved strains – pure Holstein and Montbéliarde and their crosses with native breeds – while local cattle represent less than 20 percent of total herds.

The milk yields of these different genetic groups vary considerably, particularly those of purebred dairy cows of imported strains and their crosses with local cattle. Because of their limited potential, local breeds rarely produce more than 500 kg of marketable milk per lactation. Assessments of the performance of imported strains and their crosses in different locations (irrigated, suburban and rainfed) show that the average annual milk yield per cow may vary from 1 000 to 6 500 kg (Sraïri *et al.*, 2009; Sraïri and Lyoubi, 2003). This variability is almost entirely explained by variations in feed availability and the balance of dietary rations. An important feature of Moroccan cattle systems is the very modest proportion of specialized dairy farms, as the majority of herds (more than 80 percent) belong to dual-purpose (milk and meat) smallholder units with fewer than five cows on farms of less than 5 ha each (Table 1).

According to official Moroccan terminology, any farm that delivers milk to a collection centre, even erratically, is considered a dairy unit. Currently, 790 000 farms deliver milk in this way, but only a small minority (less than 5 percent) can be described as specializing in dairy production.

All of these farms used to rely on important feed purchases (Sraïri and Lyoubi, 2003; Sraïri and Kessab, 1998), as generally heavy animal loads, limited expertise in forage production, and scarce water availability are major constraints to providing sufficient on-farm nutrients for cattle. These systems are therefore highly vulnerable to feed price variations, especially after drought periods, when live cattle prices fall sharply while feed costs rise significantly. This is particularly the case for strategic roughages such as cereal straws and alfalfa hay (Sraïri and El Khattabi, 2001). At the beginning of 2007, soaring prices of many common feed concentrates, such as cereal grains, sugar beet pulps and oleoproteaginous meals, constituted a serious threat to cattle farms' sustainability, as farm-gate milk prices remained steady.

Milk production has been increasing at almost four percent a year since the mid-1970s, although drought episodes in 1981 to 1984, 1994 and 2006 temporarily slowed the pace of expansion. By imposing high taxes on milk imports, Morocco has encouraged dairy processors to rely mainly on local raw materials, but regular imports of skimmed powder and butter have occurred, both during drought periods and to enhance the quality of locally produced raw milk products (particularly their fat content). Nevertheless, dairy imports into Morocco remain limited, at an average of 250 000 tonnes a year since 2000, representing less than 20 percent of the milk processed (Table 2). Morocco's milk imports are less than 16 percent of those in neighbouring Algeria, which has a similar population of almost 31 million people but which has adopted a clear policy of massive milk imports to satisfy domestic demand (Sraïri et al., 2007).

TABLE 1
Comparison of the performances of dairy and dual-purpose herds

Technical performance	Specialized dairy herds	Dual-purpose herds
Cattle breeds	Holstein and Montbéliarde	Crosses of local breeds with Holstein
Number of lactating cows	Usually more than 20	Fewer than 5
Average milk yield (kg/cow/year)	More than 5 000	Less than 3 000
Average profitability (US$/cow)	More than 600	About 180
Farm-gate price of milk (US$/kg)	0.38	0.33
Reproduction means	Artificial insemination (AI)	Natural service and AI

Source: Adapted from Sraïri et al., 2009.

TABLE 2
Comparison between recent Algerian and Moroccan dairy imports

Year	Algeria		Morocco	
	kg	*kg/person/year*	*kg*	*kg/person/year*
1996	1 618 486	62.7	301 432	12.3
1998	1 786 790	65.5	209 262	9.4
2000	1 814 625	66.0	245 256	10.2
2002	1 765 482	65.1	250 145	10.4
2004	1 842 765	66.3	252 120	10.3

Source: FAO, 2006.

With an annual output of almost 1.5 million tonnes of raw milk, of which 60 percent is processed by the industrial sector, and a calf crop of 1 million calves, the dairy cattle sector in Morocco provides an average annual income of almost US$856 million, based on prices of US$0.33/kg for raw milk at the farm-gate and about US$550 for a weaned calf. These figures reveal that calf sales often exceed the income from milk, as the vast majority of farms do not specialize in dairy. The calf crop is therefore more than just a by-product for dual-purpose cattle farms, and the resilience of milk production under difficult economic conditions is mainly because it provides biological support for beef production (Sraïri et al., 2009c).

Morocco's gross domestic product (GDP) was about US$67.1 billion in 2007 (Ministry of Economy and Finance, 2007), of which 17 percent – or about US$11.4 billion – was generated from agriculture and fisheries. On-farm cattle production, including both milk and calf production but not the added value generated by milk processing, therefore represents roughly 7.5 percent of total agricultural GDP.

Chapter 2
Dairy production and the environment

Currently, awareness and understanding of the environmental consequences of agricultural activities in Morocco remain weak, including those of dairy production. Until recently, very few institutional measures were taken to increase this awareness, but the drastic water scarcity that is emerging in many areas of the country (such as the oases, the southern perimeter of Souss Massa, which is an important agricultural and dairy production area, and the sub-humid Middle Atlas area) is provoking change. Other factors that affect environmental issues in livestock production are related to heavy animal loads on rangelands, particularly of beef herds and small ruminant flocks, which some authors view as being unproductive and very harmful to forest and rangeland ecosystems (Tarrier, 2003).

There is little published material on the relationship between livestock breeding and the environment, but some papers report important nitrate pollution of groundwater in areas with intensive livestock production (Laftouhi et al., 2003). Water scarcity and erratic rainfall are certainly the major challenges affecting Moroccan agriculture, and are giving rise to growing concerns about the availability and quality of water resources. In intensive irrigated crop and livestock systems (mainly of dairy cows), agricultural practices such as the use of fertilizers and manure generate massive nitrate pollution, inducing significant groundwater deterioration (Aghzar et al., 2002). Another consequence of water scarcity is the frequent use of wastewater for irrigation, which has detrimental effects on livestock health through genetic disorders (micronucleated cells in lymphocytes) (Kadmiri et al., 2006).

In such contexts, the issue of water productivity from cattle farming is attracting growing interest, particularly in regions with limited hydric reserves in the south and east of the country, where intensive dairy herds are raised. Faced with erratic rainfall, dairy farmers are relying increasingly on groundwater, which is particularly problematic in large-scale irrigated schemes where consumption rates are threatening the sustainability of groundwater aquifers (Iglesias et al., 2007). It is very difficult to analyse water productivity from irrigated cattle breeding in the Moroccan context as: i) the vast majority of farms (almost 80 percent) are smallholder units; and ii) most farms are not dairy specialized, and use irrigated forage to produce both milk and meat.

Studies show that water productivity in dual-purpose farms is low, at an average of 1.5 m^3 of water per kilogram of milk and 7 m^3 per kilogram of cattle live-weight gain (Sraïri et al., 2008), and could be improved by adopting sound farming practices along the production chain, from water use and irrigation to forage production and storage, and finally to livestock breeding.

No research has been made of dairy production's role in carbon emission or absorption in Morocco. Given the challenges currently facing the dairy chain (milk volumes and quality, farms' economic sustainability), it may be some time before such environmental issues attract much attention, unless international pressure or the physical degradation of agro-ecosystems owing to intensive milk production result in more ecological studies of cattle systems. Given the current global trend for building awareness of the environmental consequences of the livestock industry, the Moroccan authorities may soon have to implement studies and legislation to assess the impacts of dairying. This is already the case for the sanitary impacts of poultry production, as growing concerns about epidemic outbreaks (mainly avian influenza) have led to the implementation of strict rules, such as the compulsory identification of breeders.

The use of feed in milk production systems varies according to the specific situation, particularly regarding water availability. In irrigated production schemes, fodder makes an important contribution to cattle's total nutrient (net energy and digestible protein) supply. However, heavy animal loads – of up to 2.5 lactating cows and their progeny per hectare of forage – reduce the daily supply of forage to barely 7 to 8 kg of dry matter per cow (Sraïri et al., 2009c). Where the main fodder consists of leguminous crops (alfalfa or berseem), such a ration provides sufficient nutrients to ensure cows' maintenance requirements and a reduced daily milk yield (of less than 8 kg). Soaring feed prices in recent months mean that many smallholder units can no longer afford to buy off-farm resources, so milk production is more than 85 percent reliant on on-farm forage, with feed being purchased only in periods of limited fodder availability (winter for alfalfa). In smallholder units with irrigated fodder, each lactating cow therefore receives no more than 500 kg of cereal grains (mainly imported maize or local barley) per year. Calves, heifers and steers receive even less, at 200

kg/animal/year (Sraïri et al., 2009c). Before the recent price increases, these feedstuffs were often complemented by dehydrated beet pulp and wheat bran for lactating cows (Sraïri and Faye, 2004).

The use of industrial compound feed is very limited, even when feed mills make efforts to break into this potentially important market through dairy cooperatives. Morocco's compound feed industry remains oriented mainly towards poultry production, which represents almost 80 percent of the industry's total annual output, while ruminant feed accounts for less than 20 percent (450 000 tonnes out of a total of 2.5 million tonnes) (AFAC, 2007).

Given that Morocco's smallholder irrigated dual-purpose cattle farms have a total of up to 400 000 lactating cows with their progeny, these feed consumption figures imply that dairy herds consume almost 3 000 tonnes of dry matter from irrigated fodder and 1 200 tonnes of cereal grains (imported maize and/or local barley) or dehydrated beet pulps a day, amounting to about 1.2 million tonnes of dry matter from fodder and 420 000 tonnes of cereal grains per year.

In rainfed areas, the figures for dairy cattle feed consumption are rather different, as these systems suffer from frequent forage scarcities due to climatic hazards (Table 3). Feed concentrates were therefore used more frequently, before the recent price increases. Available data show that concentrates represent as much as 75 percent of the total ingested net energy in para-statal dairy farms (Sraïri and Kessab, 1998) and those in suburban areas (Sraïri and Lyoubi, 2003). This results in milk production costs being higher in Morocco than in other African countries such as South Africa, Cameroon and Uganda (Ndambi and Hemme, 2009). These figures mean that lactating cows in rainfed areas each consume an average of 10 kg of concentrates a day. The most common feedstuffs used in such herds are compound feed, cereal grains (maize and barley) and agro-industrial by-products (wheat bran, dehydrated beet pulp and citrus pulp), and the most common forages are wheat straw (which is of high strategic value in an arid country such as Morocco), rainfed oats and oats/vetch and residual berseem, maize and sorghum in small irrigated fields.

In both irrigated and rainfed areas, these off-farm feed resources represent high inputs of "virtual water", as they require large amounts of water in their production (Allan, 1998). This has to be taken into account in assessments of water productivity from cattle production in Morocco.

Imports of specialized dairy cattle breeds (Holstein [formerly Pie Noire], Montbéliarde and Fleckvieh) have radically affected the genetic structure of Moroccan herds. More than 350 000 heifers have been imported since the early 1970s, with a temporary stop from 2000 to 2004 because of the outbreak of bovine spongiform encephalopathy (BSE) in Europe. The impacts of these massive imports have not been systematically assessed, but research shows that imported animals face severe feed, hygiene and sanitary constraints. As a result, more than 40 percent are culled within three years of being imported (Sraïri and Baqasse, 2000); they do not manage to produce the expected amounts of milk and face serious reproduction troubles, mainly because of insufficient nutrient availability.

However, the imports of exotic dairy breeds have created a population of locally adapted cattle that are intensive milk producers and can, in favourable feeding and hygiene conditions, achieve interesting performances. As a result, there are now three important genetic groups: i) local breeds (Brown Atlas, Oulmès Zaër and Tidili) currently representing 1.35 million animals, or 50 percent of the total cattle population; ii) crossbreeds of local with dairy breeds, with 950 000 animals or 35 percent of the total population; and iii) purebred dairy cattle (Holstein, Montbéliarde and a few

TABLE 3
Comparison of feeding regimens in irrigated and rainfed farms with dairy herds

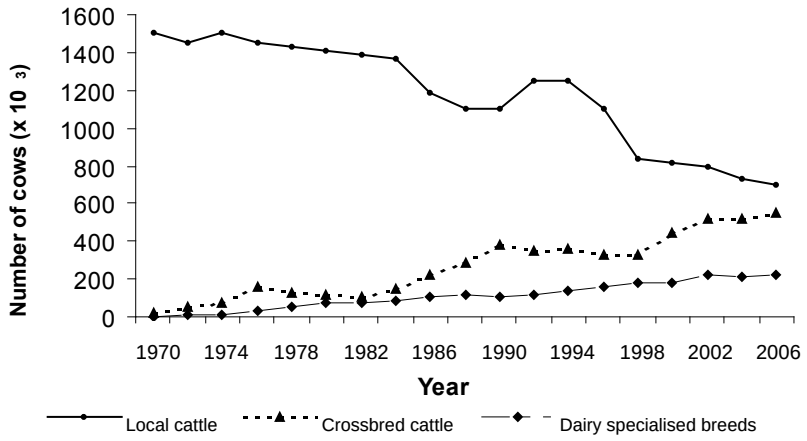
	Irrigated farms	Rainfed farms
Cattle breeds	Holstein and Montbéliarde	Holstein and Montbéliarde
Number of lactating cows	18	65
Cattle load (cows/ha of forage)	3.2	0.7
Concentrate energy (kcal/cow/year)	3 537	6 851
Forage and its origin	On-farm alfalfa and maize silage	On-farm oat and triticale off-farm alfalfa hay and straw
Forage dry matter (kg/cow/year)	2 555	2 300
Average milk yield (kg/cow/year)	5 075	4 915
Milk production cost (US$)	0.27	0.33
Gross margin per cow* (US$)	1 125	278

* Including calf sales.
Sources: Adapted from Sraïri et al., 2008; Sraïri and El Khattabi, 2001.

Fleckvieh) with 400 000 animals, or 15 percent of the total. The shares of different genetic groups in the total reproductive cow population have changed since the early 1970s, when local strains represented more than 90 percent of the total (Figure 2).

Reports agree that this may have resulted in some genetic erosion of local cattle breeds, as they have been extensively involved in crossings. Some local breeds, such as Oulmès Zaër, are the focus of conservation projects to avoid the loss of their characteristics (Asri, Aïttaleb and Duplan, 1991).

FIGURE 2:
Evolution of cow numbers in different genetic groups in Morocco



Source: Adapted from MAMF, 2007.

Chapter 3
Dairying and livelihoods

The Dairy Plan was launched in the 1970s to create a country-wide activity that generates steady income for rural households. Few data specify the importance of milk production in rural households' overall income, as the agriculture sector is not subject to taxes and on-farm records are limited. However, dairy farming is certainly a strategic activity for smallholder units raising a few cows and their progeny, and can provide annual gross margins of US$183 to $610 per cow, ensuring a steady income (Sraïri *et al.*, 2009b). Calf sales are also strategic when households face important social and agricultural expenses. Given annual gross revenue of almost US$825 from milk (based on an average of 2 500 kg of milk per cow, sold at a unit price of US$0.33), plus some US$550 per calf, each dairy cow can generate an annual income of about US$1 380 (Table 4), equivalent to about half of Morocco's per capita GDP in 2008 (US$2 570). This is achieved by the use of renewable energy resources that create sustainable labour opportunities and produce high-quality animal protein.

However these average figures should be considered with caution, as cattle performances and income are highly variable. In irrigated areas, the incomes generated from dairy cows are more steady, although other crops (sugar beet, cereals, horticulture, etc.) can be more lucrative than cattle breeding. Dairy cattle are vital to most farms, as a secure income source (the milk price is steady) and contributor to soil fertility. The situation is less secure in rainfed areas, which face climatic hazards as dairy cattle breeding is closely linked to rainfall levels. In acute droughts, many farms prefer to get rid of their animals and wait until rainfall has returned before they buy more cattle, so long periods of drought significantly alter the income and economic margins of dairy businesses in rainfed areas.

The main operators and activities in the dairy chain are summarized in Table 5, which shows the structure of the dairy chain from milk production to collection, processing, retailing, and the monitoring and regulation of activities.

Dual-purpose cattle production is a very important tool for alleviating poverty, and Moroccan authorities should encourage small-scale dairy development projects. The National Initiative for Human Development, launched in May 2005, promotes animal production projects based on the distribution of dairy goats and rabbits to vulnerable social categories (poor women and young unemployed people). The authorities prefer to promote goat farming, as goats require fewer initial investments than cattle. It is too early to draw conclusions about the performance of these projects, but significant funds are still being mobilized for them.

At present, the most important challenges to dairy development throughout Morocco remain the improvement of milk quality and yield. As the public sector is currently disengaging from production activities, it is expected that private operators will organize themselves to achieve these objectives. The industrial milk processing sector will therefore be a key component in any changes, as it has the financial means and can drive progress further along the dairy chain. It already collects up to 60 percent of total raw milk production, and could establish milk quality standards and assist farmers' cooperatives in satisfying them.

Developments are already under way, as dairy processors' strict instructions to destroy raw milk batches containing antibiotics are being applied in cooperatives. This has led the executive members of milk collection cooperatives to insist that farmers do not deliver milk from treated cows. Such developments would have been impossible ten years ago.

Dairy processors could also promote improvements to milk yields, as they supply farmers with strategic inputs (especially imported heifers, feed and small milking machines), which farmers pay for from the additional milk produced. This

TABLE 4
Income potential from dairy farming

Product	Quantity	Unit price (US$)	Average income (US$)
Milk (kg/cow/year)	2 500	0.33	833
Calves (number/cow/year)	1	550	550
Manure	-	-	-
Total	-	-	**1 383**

trend is illustrated by the recent partnerships in irrigated schemes, involving cattle farmers' cooperatives, dairy processors, compound feed producers and State agricultural agencies, to promote higher milk output and thereby increase overall incomes for supply basins. Such initiatives have evident social and political consequences, in seeking to alleviate poverty and increase employment opportunities for vulnerable people.

TABLE 5
The Moroccan dairy value chain and its main operators

Production	**On-farm activities** - Milk production - Fodder production - Feeding cattle - Milking cows - Herd management	**Structure/systems** - 700 000 smallholder dual-purpose units (fewer than 3 cows each on average) - 40 000 specialized units (average annual milk yield > 5 000 kg/cow) - Very few large farms with more than 100 lactating cows
Milk collection	**Activities** - Basic quality testing (density, colour) - Cooling in collection tanks - Management of collection cooperatives	**Structure** - Almost 1 000 cooperative dairy collection centres - 50 private dairy collection centres - An unknown number of milk pedlars - From US$0.02 to $0.04 per kg of milk

Transport, processing and packaging	**Activities**
	- Processing dairy products (pasteurized milk, yoghurt, butter, cheese, etc.)
	- Advanced raw milk testing (bacterial oad, antibiotics residues, fat and protein contents, etc.)
	- Various packaging presentations
		Structure
		- 44 dairy societies operating in formal milk processing chains collecting, transporting and processing raw milk before selling it to retailers, of which:
		  - 2 large (processing more than 50 tonnes of raw milk daily), 1 totally private (Centrale laitière) and 1 cooperative (Copag)
		  - 32 medium-sized dairy societies (processing 10 to 50 tonnes of raw milk daily), 22 cooperatives and 10 private structures
		  - 10 small dairy processing societies (processing 2 to 10 tonnes of raw milk daily), almost all private
		An unknown number of dairy workshops (mahlabates) operating in informal milk circuits
		60% of milk produced processed by formal circuits, and an estimated 10% by informal operators
		Processing costs vary depending on type of processing, label of products, etc. Can be up to 100% of the raw milk farm-gate price

Retailing	**Activities** - Sales to individuals and/or institutions - Delivery - Storage	**Structure** - Fixed premises: shops, supermarkets – less than US$0.1/kg pasteurized milk - Traditional milk processors: US$0.2–0.3 of margin per kg of milk, depending on product (traditional yoghurt, salted butter, etc.)
Organizations and institutions	790 000 cattle farms in 1 000 dairy cooperatives represented by 19 regional associations 1 processors' association gathering dairy cooperatives	**Government/public institutions involved in the dairy value chain** - MAAR and its local representatives in different regions of the country: gathering statistics on dairy activities, animal health care - Institutes and schools of agriculture: training dairy specialists and veterinarians

Chapter 4
Employment in the dairy sector

The issue of labour creation in the dairy chain is gaining increasing interest in Morocco, which faces massive unemployment. There are no official data about the total jobs provided by the dairy chain, as many on-farm and informal milk collection activities are not documented. However, follow-up on cattle production practices has allowed some quantification of labour needs. It appears that specialized dairy herds require an average of 30 working days per cow and its progeny, which means about one permanent job per ten to 15 cows and their progeny (Sraïri and El Khattabi, 2001). If five percent of cattle farms are considered to be dairy units, dairy farming could create about 40 000 full-time jobs throughout the year.

For less specialized herds, which often rely on non-remunerated family labour, research data from smallholder units (with fewer than five cows and their calves) show that at least one household member is mobilized all day long cutting forage, feeding and milking cows, cleaning the barn and delivering milk twice a day to the cooperative (Sraïri *et al.,* 2008). This means that some 700 000 people are occupied in activities related to dual-purpose (milk and meat) cattle production. The workforce engaged in on-farm milk production is therefore about 740 000 people (Table 6).

Nationwide there are almost 1 000 milk collection centres managed by dairy cooperatives. Each cooperative generally provides steady jobs to at least two people – a milk receiver and an assistant, who also help run the other services provided by the cooperative, such as a grocery store to supply farmers with basic goods (tea, sugar, etc.) or a telephone centre. (Cooperatives are often located in small villages, where farmers have limited access to such facilities.) Therefore, about 2 000 people are employed in the formal milk collection sector.

Milk processed by the industrial sector has to be transported from the cooperatives to the plants. At this level, official data suggest that the dairy industry creates about 10 000 steady jobs (Mission Économique de l'Ambassade de France à Casablanca, 2004).

In addition, there are various types of employment in informal milk collection and transformation activities, particularly in the supply basins near important urban centres, where city dwellers sometimes prefer to consume traditional dairy products in milk shops (*mahlabates*). There are no official data regarding these activities, which are officially illegal; legislation is clear that all the milk destined for human consumption should be industrially pasteurized to avoid health risks. However, to prevent social tension, especially since the implementation of structural adjustment programmes, the Moroccan authorities tolerate cattle farms' direct sales through informal circuits, particularly in the environs of important cities. For example, it is estimated that more than 3 000 *mahlabates* are active in Casablanca alone (Letheuil, 1999), which means almost 6 000 people are working in this sector. Nationwide, there could be about 20 000 people working in informal milk collection and processing.

Altogether, some 772 000 people have steady jobs from the dairy chain, excluding the retailers who supply consumers. This implies that 10 percent of agricultural labour opportunities are provided by the dairy chain, given that the Moroccan labour force is 15 million people, of whom more than 7.5 million work in the agriculture sector. This important share is partially explained by the dual-purpose character of dairy cattle, as a significant part of the beef produced in Morocco is generated from herds classified as dairy.

TABLE 6
Labour creation along the dairy chain

Activity	Specialized herds	Dual-purpose herds
On-farm labour (steady year-round jobs)	40 000	700 000
Off-farm labour		
Formal milk collection	2 000	
Industrial milk processing	10 000	
Informal milk collection and processing	20 000	
Total	**772 000**	

There are no accurate data on the incomes generated by these various activities. In Morocco the agriculture sector is not subject to tax, so farms do not keep records of their economic activities, particularly because most smallholder farmers are illiterate. However, investigation of the activities of some cattle farms show that cattle profitability in irrigated, suburban and rainfed zones is relatively limited, averaging US$185 per lactating cow per year, and highly variable, fluctuating from a loss of US$1 065 to a gain of US$1 470 (Sraïri *et al*., 2009b), including calf sales. The social roles of dairying, such as the employment it provides and the important contribution farmers' cooperatives make in their communities, and dairy farms' contribution to land fertility, through manure production, are significant assets that explain its robust resilience. However, some farms are losing money because of inappropriate practices, such as insufficient nutrient supply to herds, inadequate resources for buying off-farm feed, poor reproduction management, etc. (Table 7).

More accurate data are available on dairy farms, as some of these keep up-to-date records of their milk deliveries and input purchases. Published references show that a Holstein cow generates average annual profits of almost US$855, producing 5 500 kg of milk a year and calving every 13 to 14 months (Sraïri *et al*., 2008). However, such results are highly variable, as the economic profitability of dairy cattle is closely linked to climatic hazards (Sraïri and El Khattabi, 2001), particularly in rainfed agriculture regions, where annual profits may fall from US$610 to less than US$305 per lactating cow after a severe drought.

For smallholder unspecialized units, there are no profitability data. A recent study of irrigated schemes found that many farms appear to lose money when milk is considered as their only product (Sraïri *et al*., 2008), but when calf sales are included, annual economic performances rise to an average gross margin of US$ 490 per cow. Similarly modest gross margins have been found in many parts of the country, indicating that cattle farming often has a limited economic role (in addition to its roles in soil fertility preservation, labour opportunities, gender issues, etc.) (Sraïri, Leblond and Bourbouze, 2003).

Dairy cattle production seems likely to provide more labour opportunities, as forecasts indicate that there will be increased demand for dairy products. This is an ongoing trend, and State authorities are providing incentives to private investors, mainly by facilitating their access to agricultural land. Many schemes involving hundreds of dairy cows are currently being designed or launched, and these will require more labour, technology and trained animal scientists. Such projects are expected to be a driving force for upgrading the whole cattle sector and establishing competitive farms, particularly in the context of a free trade agreement with the EU. At the same time, however, such an upgrading of the Moroccan dairy chain may also drive many smallholder units with limited financial means and expertise out of the sector, thereby reducing the employment opportunities provided by the dairy chain. These possible developments will be closely linked to the evolution of the Moroccan domestic dairy chain and its competitiveness with imported goods.

TABLE 7
Calculation of the gross margin per cow in a dairy herd

	Quantity	Unit price (US$)	Total (US$)
Products			
Milk yield per cow (kg)	5 500	0.38	2 090
Calf	1	500	500
Total	-	-	2 590
Variable costs			
Concentrates (kg)	3 000	0.28	840
Roughage			
On-farm (produced)			594
Off-farm (purchased)			250
Veterinary expenses	-	-	50
Gross margin	**-**	**-**	**856**

Source: Adapted from Sraïri *et al*., 2008.

Chapter 5

Safety of milk and dairy product

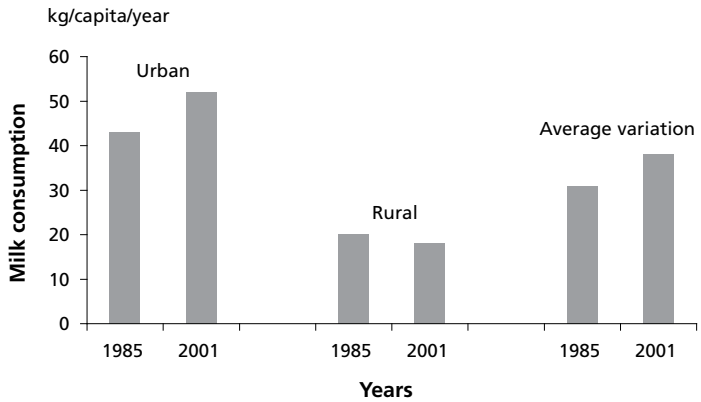
Milk and dairy derivatives constitute an important source of animal proteins in the Moroccan diet, but there are significant sanitary risks associated with milk consumption, particularly of raw unpasteurized products. Much recent research work attests that raw cattle milk is generally heavily contaminated by microorganisms (Sraïri *et al*., 2009a; Mennane *et al*., 2007), often with counts of more than 10^6 colony-forming units (cfu) per millilitre. The contamination of traditional dairy derivatives, such as *jben* (cheese) or *raib* (fermented milk), by pathogens such as *Yersinia enterocolitica* has also been assessed (Hamama, Marrakchi and Othmani, 1992), and more recent studies have characterized the presence of other pathogenic bacteria such as *Staphylococcus aureus* in traditional cheeses (Hamama *et al*., 2002). This contamination is due to inappropriate hygiene practices at the farm level, and could generate health hazards for human consumption.

Legislation therefore requires that all raw milk must be pasteurized. Short milk marketing circuits should be avoided, but continue to function in large cities, as some consumers (especially those of rural origin) prefer traditional dairy preparations (*jben, raib, smen,* etc.), and often use raw unpasteurized milk in contexts were milk for drinking is generally boiled. Such behaviour is risky, and research results suggest that there have been outbreaks of zoonoses such as brucellosis in Moroccan citizens migrating to other countries (Ramos *et al*., 2008). Another serious health risk is the possibility of tuberculosis (TB) infection from raw milk consumption, as official data suggest that the prevalence rate of TB reached 18 percent of total herds in 2004 (Berrada, 2005). Other research has investigated the potential risks of aluminium, lead and other trace elements such as zinc (Zaida *et al*., 2007), which might contaminate humans through the consumption of milk and its derivatives. Such contamination has been observed particularly among infants in urban areas.

The consumption of milk and dairy derivatives remains low in Morocco, at an annual average of 38 kg per capita, far below the internationally recommended 90 kg. This represents a supply of 3.2 g of protein, constituting about 30 percent of total animal proteins in the Moroccan diet (10.3 g/capita/day) (MAMF, 2007).

The increase in milk production over the last 30 years has kept up with demographic expansion, but had not been sufficient to improve the per capita availability of dairy products. The mean annual consumption of 38 kg/capita hides very wide variations, depending on the place of residence and other factors (Figure 3). Official data suggest that annual milk consumption can reach almost 90 kg per capita in rich urban households, while it is only 18 kg in poor rural ones. Research results indicate that the policy of collecting milk through cooperatives has had a negative impact on on-farm and rural consumption, which dropped from 22 to 18 kg/capita/year between 1985 and 2001 (Figure 3), as many farmers deliver all their daily output to increase their incomes. Rural children are the ones who suffer most from the reduced on-farm availability of crude milk (Benjelloun *et al.*, 1998).

FIGURE 3
Evolution of dairy product consumption in Morocco



Analysis of dairy consumption shows that it is dominated by pasteurized milk (80 percent), as derivatives – particularly yoghurts and cheese – are generally viewed as luxury products because of their high prices (Sraïri and Chohin-Kuper, 2007). However, recent developments in dairy product marketing (e.g., "light" goods) and the emergence of shopping malls, supermarkets and a network of traditional dairy product cafés (*mahlabate*) are affecting consumption. This is occurring simultaneously with vast social changes, such as rapid urbanization and an increase in eating meals outside the home, which are also likely to have tremendous impacts on dairy product consumption, although very little research has been made into these developments.

The future evolution of milk consumption in Morocco will certainly be closely linked to the economic development of the country and the income of its citizens. The global demand for animal products is expected to rise significantly, particularly in emerging countries (Delgado, 2003) such as Morocco. However, this can be achieved only with a significant increase in wealth and a more even distribution of that wealth, as many people's milk consumption is still limited by continuous price increases for both pasteurized milk and its derivatives and by stagnating and declining incomes.

The entry of multinational companies such as Danone and Nestlé into the Moroccan market has had tremendous impacts on domestic industrial dairy processing, and has led to the upgrading of dairy products, which benefit from these multinationals' expertise. As a result, a large proportion of locally processed dairy products (pasteurized milk and derivatives such as yoghurt) now provide sufficient guarantees of quality. In fact, most outbreaks of food-borne infections associated with toxins in dairy products are related to raw milk or its derivatives from the informal processing chain, which do not have the same hygiene requirements as the industrial sector. Current legislation has adapted to this situation by demanding that all raw milk products be processed by the industrial sector. Informal circuits constitute an exception to this rule, but their weight in the overall dairy chain is moderate; given their important role in milk collection, private industrial processors will remain key actors in ensuring the safety of dairy products. Developments are already under way, as milk collections are becoming more frequent (rising from one to two a day in major supply basins) and dairy plants have begun to classify raw milk batches according to their microbial load, with important rewards for cooperatives with good hygiene. Regions and/or cooperatives whose milk has heavy microbial loads are likely to be paid less, or have their milk refused.

Chapter 6
Dairy institutions

With the launching of the Dairy Plan in the mid-1970s, State authorities started to intervene throughout the dairy chain, from providing extension on appropriate agricultural practices and veterinary treatments for cattle, to supervising farm-gate milk prices, and including the introduction of incentives for setting up milk collection centres. The implementation of structural adjustment programmes brought a significant shift in dairy policy, leading to the progressive disengagement of State technical services and the emergence of a private sector to manage the whole dairy chain.

The State authorities have encouraged the establishment of cattle breeders' associations, private veterinary surgeries, autonomous artificial insemination circuits, etc. From being a State monopoly in the mid-1970s, the dairy chain has evolved significantly with the appearance of independent actors. Today, the private stakeholders involved in dairying are:

a) cattle farmers, with diverse production means (number of cows and arable area) and performance levels (annual milk yield per cow and economic profitability);
b) milk collection cooperatives – which are often run by an executive bureau and for which the essential performance indicator is the annual volume of milk delivered to dairy plants – and possibly their annex activities (grocery stores, telephone shops, etc.);
c) milk collection actors in informal dairy chains, mostly around important urban centres;
d) industrial milk plants, which can be divided into two categories, i) private holdings, often associated with multinational dairy companies; and ii) cooperatives, in which cattle farmers own shares;
e) informal milk shops (coffeeshops and mahlabates);
f) suppliers of services (veterinarian, insemination) or commodities (feed concentrates).

Whatever their size and performance, dairy farmers defend their own interests through milk collection cooperatives. Through these cooperatives, or as individuals (particularly those with big herds who deliver their production directly to dairy plants), farmers can also group themselves into regional cattle breeders' associations, which are federated at the national level in the National Association of Cattle Breeders (*Association Nationale des Éleveurs de Bovins* ANEB). ANEB represents almost 17 regional groups and some individual farmers (mainly large-scale cattle farmers) and is the official institution for representing Moroccan cattle farmers, particularly regarding such topics of national interest as drought alleviation plans, outbreaks of epidemic diseases, revision of farm-gate milk prices, and farmers' position in the ongoing free trade negotiations with the EU. ANEB is meant to defend the interests of all categories of cattle farmers.

However, the high number of cattle farms involved in the dairy chain results in a segmented supply, with relatively small volumes delivered by numerous farms, making it difficult to provide all milk producers and industrial processors with equal opportunities in negotiations (Sraïri and Chohin-Kuper, 2007). This is particularly the case for farm-gate milk prices and quality remuneration. Under the two-stage dairy chain (farmer to cooperative, and cooperative to processor), individual farmers with good-quality milk (high fat and protein contents and low microbial contamination) are not rewarded for their efforts, as the samples assessed by industrial dairy processors come from the pooled milk of all the cooperative's members (Sraïri *et al.*, 2009a).

Recent assessments of the performance of milk collection cooperatives' and their roles in rural areas of Morocco found that there are almost 1 020 milk collection centres nationwide. A vast majority of these are managed by cooperatives, and very few are privately owned. These centres play a crucial role as the intermediaries between thousands of smallholder farms and a few industrial plants. They therefore have to manage daily flows of milk – and sometimes also feed sold to farmers – and of information (milk delivery data) from several farms. This is a complicated management task requiring skills that are not always available, and many milk collection centres face management difficulties (Le Gal *et al.*, 2007) that affect their overall performance and result in frequent breakdowns (Sraïri and Medkouri, 1999).

Milk processing institutions can be classified into four main categories (Table 5). The first category is the private industrial sector, dominated by the *Centrale laitière,* which currently handles more than 60 percent of the annual milk volumes processed industrially. It is therefore the most important actor in milk processing and has strong ties to the multinational Danone, which provides it with two important assets: technical expertise and the ability to sell products under the Danone label (El Ameli, 2005). Nestlé is also present in the Moroccan dairy chain, but is active mainly on

high-value products such as ice cream and milk powder, and processes only 7 percent of the volumes collected by the industrial dairy chain.

The second category of milk processors is represented by the cooperative Copag (*Coopérative Agricole d'Agrumes*), which has developed over the last ten years in the southern region of Souss-Massa to become a strong competitor to *Centrale laitière*. Copag now handles almost 20 percent of the volumes processed by the dairy industry, and its market shares are steadily growing (Sraïri and Chohin-Kuper, 2007), as its milk derivatives are of supermarket quality. Its cooperative status wins Copag a certain amount of consumer approval.

The third category of milk processors is very complex and segmented, as it comprises the numerous small processing cooperatives that operate in narrow supply basins. Some of these cooperatives are struggling to survive in the face of financial and technical problems, such as increases in the prices of raw milk and other strategic inputs (skimmed milk powder, butter, fossil energy), a narrow range of milk derivatives that are not of supermarket quality, and limited expertise in milk transformation. Most of these cooperatives sell mainly pasteurized milk, which has smaller economic margins than dairy derivatives. It is expected that some of these cooperatives will have to upgrade their operations in the near future, by either merging activities or adopting rational practices, from milk collection and processing to product marketing (El Ameli, 2005).

The last category of milk processing unit are the traditional milk shops known locally as *mahlabates*. These are present only in urban areas, and have strong business opportunities, albeit it in a narrow niche. There are no official data specifying the exact volumes of milk sold by this informal sector.

The public sector operates in the dairy chain through diverse institutions and actors. First of these is MAMF and its local agencies, which are responsible for monitoring the health status of herds and periodically gathering data on cattle numbers and their variations, milk yields and quality performances. These institutions issue and administer authorizations for cattle imports, as since 2004 farmers must commit themselves to keeping imported cattle for at least four years, to ensure acceptable careers for dairy heifers (Table 8).

TABLE 8
Public and private sector responsibilities in Morocco's dairy industry

Service	Responsibility	Funding	Oversight	Comments
Breeding services	Private	Private	Public/private partnerships	Still very fragmented, encouraging important efforts to upgrade milk productivity and quality
Clinical veterinary services	Private	Private	Veterinary association	Almost 650 private veterinarians active in surgeries throughout the country
Preventive veterinary services	Public	Public/ private	Public	Only for foot-and-mouth disease, implemented mainly by contracts through private veterinarians
Food safety requirements	Public	Public	Public	Based mainly on random analysis of zoonosis threats
Advisory services	Private/ public	Initially public with cost-sharing Currently shifting towards the private sector	Private/public	Mainly private delivery, as the State disengages from services provision. Many animal science specialists currently working with private farms and milk processing units Some civil servants working with private operators to share their knowledge and experience
Milk collection	Totally private	Private: no more State incentives	Private	Dairy industrials have the financial capacity to enhance milk collection throughout the country, and will recoup their investments through the margins on processing
Milk processing	Private	Mainly private	Private	Small non-competitive structures are likely to merge in the near future
Research	Totally public	Public	Public/private	Public funding, with an important role for international cooperation In the near future, focus should be on refreshing research staff and orienting research towards dairy topics such as milk quality, water productivity from cattle farming and the resilience of smallholder farms
Education	Public	Mainly public	Public/private	Important changes might occur during the ongoing liberalization, including more private sector participation in agricultural education
Input supplies	Private	Public contracts to safeguard herds in case of drought	Private, reduced public monitoring of quality	Feed supplies all ensured by private operators State services still supply semen for local artificial insemination

State agricultural authorities have also been engaged in drought alleviation programmes for the livestock sector, particularly the distribution of subsidized compound feed throughout the country (Rihani and Bouslikhane, 2002). These operations have helped cattle farmers to avoid heavy losses in cattle numbers, although during the acute drought of 2007, which coincided with rising feed prices on international markets, the State's interventions were limited.

As the State progressively disengages from the agriculture sector, some of the civil servants who were active in the dairy sector (milk recording agents, inseminators, etc.) are being transferred to private institutions (dairy cooperatives, local and national cattle associations, etc.), so they use their expertise to help the dairy sector develop.

The public sector is also in charge of training the animal scientists, veterinarians and technicians who participate in dairy development. This training is carried out at two graduate schools – the Hassan II Agronomy and Veterinary Medicine Institute in Rabat and the National School of Agriculture in Meknes. Each year, almost 20 animal science graduates and 40 veterinarians join the labour market, where some are recruited by dairy chain operators such as cattle farmers' associations, private sector farms and dairy processors. Some veterinarians set up their own surgeries, and a significant proportion of these provide medical care to private herds.

The public sector also used to manage large State-owned dairy cattle farms, which performed well. The milk yields and production of some of these farms could be considered a model for milk intensification in Morocco, with figures of more than 6 000 kg per lactation and an average annual gross margin of US$610 per cow (Sraïri and Kessab, 1998). Nevertheless, these farms were privatized at the beginning of 2005 as part of the State's disengagement process, and all State-owned farms with good production potential are now rented by private actors.

Another important consequence of the State's disengagement from the dairy chain is the complete liberalization – since 1992 – of milk prices at the farm level and for the consumer. However, over the last 15 years, dairy farmers feel that the raw milk price has remained the same, while the price of milk for consumers has steadily increased (Table 9).

As a consequence, there is ongoing debate in the dairy chain, with many cattle farmers arguing that they are working merely to increase dairy processors' margins. Only in 2008, after a marked increase in feed costs, did industrial processors finally concede a slight increase in the milk price for farmers, but they reported this to consumers. Milk production costs appear to vary according to fodder availability (i.e., rainfall or irrigation volumes), cows' milk yields and reproduction performances (Tables 10 and 11). In many situations, the milk production cost seems to be higher than the milk price at the farm-gate (which is less than US$0.32 in many regions), suggesting that only calf sales enable farmers to generate positive economic results from their dairy activities.

The dairy chain is evolving through the trend for privatization, as the vast majority of its main productive activities are carried out by private operators. This rapid change is full of uncertainties, however, and some important activities, such as recording of milk production, and tuberculosis and brucellosis prophylaxis, are only partially covered.

The disengagement of State technical staff has resulted in a lack of agricultural extension to farms, and the majority of farmers no longer receive advice about balanced dietary rations, management of herd reproduction, etc. The private sector is expected to upgrade the dairy sector with its own means, although State subsidies and incentives might also contribute to achieving this goal. Efforts are currently being made to address some of the challenges facing the dairy

TABLE 9
Evolution of farm-gate and consumer prices for milk in Morocco

Year	Farm gate milk price (1)	Milk price at consumption (2)	(1)/(2)
	(Moroccan dirhams)		*(%)*
1970	0.54 (0.06)	1.05 (0.12)	51.4
1975	0.90 (0.10)	1.20 (0.13)	75.4
1980	1.44 (0.16)	2.10 (0.23)	68.6
1985	2.05 (0.23)	3.10 (0.34)	66.1
1990	2.62 (0.29)	4.10 (0.45)	63.9
1995	2.94 (0.33)	5.00 (0.55)	58.8
2000	2.94 (0.33)	5.40 (0.60)	54.4
2005	2.94 (0.33)	6.20 (0.69)	47.4
2009	3.00 (0.33)	6.40 (0.71)	46.9

Figures in brackets are prices in United States dollars.
Source: Adapted from Sraïri and Chohin-Kuper, 2007

TABLE 10
Calculation of milk production costs in an irrigated dairy herd

Variable production costs	Feed units	Price per feed unit (US$)	Total
Feed cost per cow (US$)			
On-farm forage	2 785	0.15	417
Purchased forage	600	0.35	210
Concentrates	2 080	0.28	583
Veterinary treatments	-	-	60
Average milk yield (kg/cow/year)	5 075	-	-
Milk production cost (US$)	**-**	**-**	**0.27**

Source: Adapted from Sraïri et al., 2008.

TABLE 11
Calculation of milk production costs in a rainfed dairy herd

Variable production costs	Feed units	Price per feed unit (US$)	Total
Feed cost per cow (US$)			
On-farm forage	1 770	0.12	212
Purchased forage	1 350	0.33	445
Concentrates	3 830	0.24	919
Veterinary treatments	-	-	50
Average milk yield (kg/cow/year)	4 915	-	-
Milk production cost (US $)	**-**	**-**	**0.33**

Source: Adapted from Sraïri et al., 2008.

sector through, for example, improved use of water resources, construction of modern barns and stalls, and acquisition of machinery such as tractors and milking parlours.

Performance and quality improvement is receiving growing attention as a way of increasing cattle farmers' income, and the emergence of environmental issues is putting farmers and processors under increasing pressure to adopt good management practices. This is particularly true of water productivity issues, as Morocco already faces water shortages, even in irrigated areas, which are threatening its long-term development.

These challenges will require the intervention of highly trained human resources and the clarification of responsibilities along the whole dairy chain. All the institutions, both private and public, operating in the Moroccan dairy chain will therefore have to upgrade themselves and work in association to achieve sound governance of the subsector's affairs.

Chapter 7

Analysis of the dairy value chain

The current organization of milk marketing circuits in Morocco can be divided into three main chains:

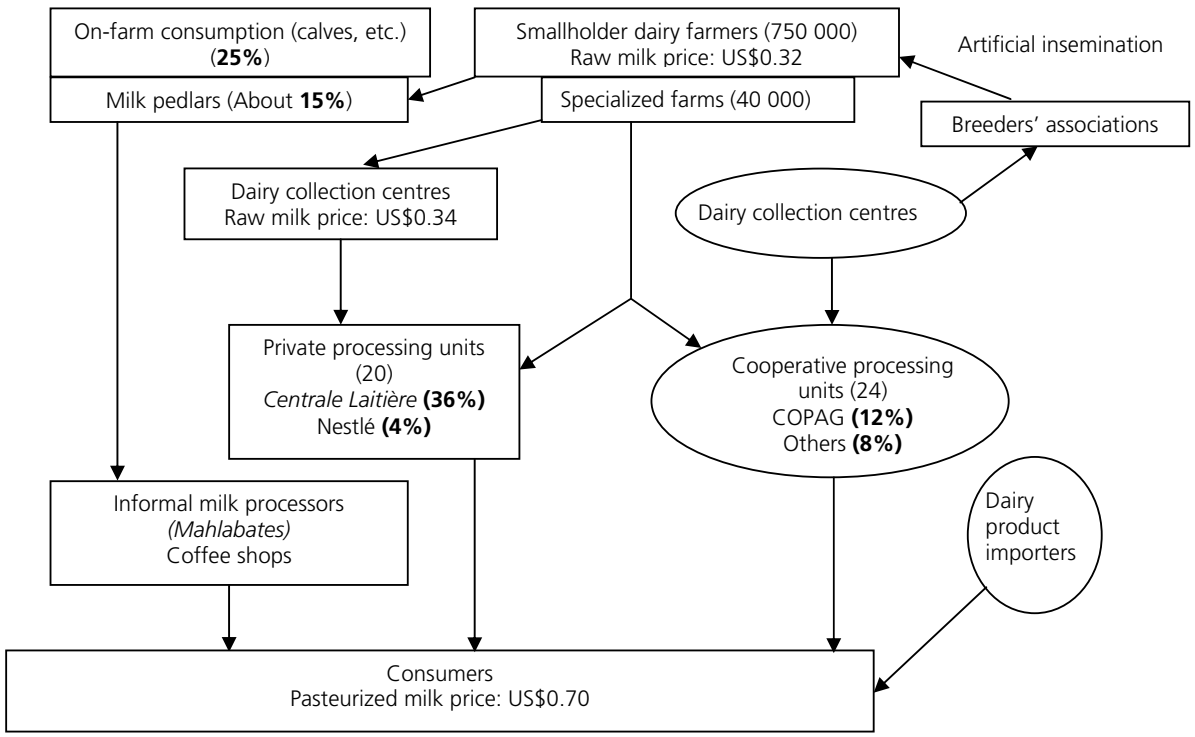
1. a formal private circuit, from farms, through milk collection cooperatives, to industrial dairy processors and on to distribution to consumers;
2. a formal cooperative-based circuit, similar to the private one but with dairy processing based on farmers' cooperatives;
3. an informal short circuit, with milk processed into traditional products by small workshops and sold directly to consumers.

It therefore appears that it is essentially the kind of processor that determines the nature of the milk chain. A brief analysis of these dairy circuits shows that they are all supplied with raw milk from numerous types of farms, a vast majority of which are smallholder units. The first two types of chain process important volumes daily (more than 50 tonnes each for the largest operators) and rely on milk collection through intermediate milk collection cooperatives.

These characteristics put the formal industrial milk processing chains in an unusual position compared with that in neighbouring countries: they work essentially with locally produced raw material (unlike in Algeria, where they work with milk reconstituted from imported powder), and they are active all year round (unlike sub-Saharan dairy processors, whose activities are essentially seasonal) (Corniaux et al., 2005).

According to official data, the industrial dairy processing sector represents more than 60 percent of the annual output of cattle milk (MAMF, 2007). The remaining 40 percent is used by suckling calves, consumed on dairy farms or sold into informal circuits (Figure 4).

FIGURE 4
Operators in the Moroccan dairy chain



Footnotes:
(20) - Number of operators
(**12%**) - Percentage of milk processed

The industrial milk processing sector is dominated by the private operator *Centrale laitière,* which processes the output of more than 110 000 dairy farms, collected from 300 milk collection cooperatives and 200 large farms (*Centrale laitière,* 2008). Its farm-gate milk price is roughly the same throughout the country, at US$0.37 per litre during the dry season (15 August to 14 February) and US$0.32 in the wet season (15 February to 14 August). Payments are made to milk collection cooperatives, which deduct US$0.018 to $0.024 per litre to cover such expenses as energy for milk cooling, labour remuneration, artificial insemination and social expenses. This means that farmers get only US$0.34 and $0.29 per litre in the dry and wet seasons, respectively. Payments for raw milk in this two-stage dairy chain (farm to collection centre and on to the industrial plant) is made more complicated when industrial processors reward cooperatives for high-quality milk (with a fat content of more than 35 g/kg) and fine them if the quality is low. These premiums do not benefit individual farmers, but are passed into the cooperative's cash-flow and used to finance collective services such as restoring roads and improving health care for farmers.

Centrale laitière tries to increase raw milk output in the supply basins where it operates by intervening through collection cooperatives. For example, it may help farmers to buy heifers or provide them with financial support for purchasing concentrates. Farmers pay back these investments from the additional volumes of milk they produce. Training sessions are sometimes organized to explain feeding techniques or new technologies (drip irrigation, maize silage, automatic milking, etc.) to farmers.

The raw milk collected by the industrial plant is processed and used in dairy preparations. *Centrale laitière* currently manages five plants nationwide, each of which specializes in a specific kind of product: pasteurized milk, ultra-high temperature (UHT) milk, yoghurts, cheeses, etc. As a local representative of Danone, *Centrale laitière* applies international safety and quality standards to its dairying procedures and has been certified by the International Organization for Standardization (ISO) since 2001. The partnership with Danone gives *Centrale laitière* access to high-quality inputs for dairy products packaging, such as tetra packs.

Centrale laitière's high-margin products, such as yoghurts, cheeses and frozen desserts, also benefit from Danone's expertise, with some of the most expensive ones bearing the Danone brand, while cheaper products have local brand names, such as Yawmi. *Centrale laitière*'s products are distributed throughout Morocco by a vast network of retailers covering outlets that range form modern supermarkets to local grocery stores. In January 2009, its pasteurized milk price was US$0.70 per litre, and an average *Centrale laitière* fruit yoghurt is sold for about US$0.22. *Central laitière* has recently begun selling UHT drinking milk and has developed a special brand for children called Moufid.

The cooperative industrial dairy chain relies mainly on Copag, which processes 20 percent of total milk volumes in the industrial circuit. Copag was created in May 1987 in the southwestern region of Souss Massa, an arid region with less than 200 mm mean annual rainfall, where dairy farming allows smallholder units to produce much-needed manure for intensive horticultural crops (such as citrus and tomatoes) for export. However, the depletion of groundwater aquifers has put Souss Massa's dairy industry at risk, and the regional investors who lead the Copag cooperative are progressively shifting their activities further north, where they have obtained access to large irrigated areas of more than 1 500 ha, with the support of State authorities.

Copag is still active mainly in its original southern region, where it collects milk from 170 individual farms and 69 cooperatives with more than 14 000 smallholder members. From this, Copag processes about 150 000 tonnes of raw milk a year, generating almost a third of the gross income of its direct competitor, *Centrale laitière.* In accordance with its cooperative status, Copag implements development interventions in the dairy farming sector. It is very active in artificial insemination (with 40 000 in 2008) and seeks to make genetic improvements through the use of imported semen. Copag has also started its own compound feed production unit (80 000 tonnes in 2008), to enhance on-farm milk output. Copag has to manage the same constraints as other operators: segmented supply from numerous smallholders, and highly variable milk quality deliveries.

As a cooperative structure, Copag is not devoted to making profits for itself, and instead distributes profits among its members. In the past, it did not pay taxes on its gross margin, which allowed higher farm-gate prices of almost US$0.43 throughout the year (Copag does not differentiate between wet and dry seasons as it operates in an arid zone). In 2007, however, changes in the Moroccan fiscal system included the payment of taxes by large-scale cooperatives, which has had a serious impact on Copag's net returns.

Copag's marketing success is mainly the result of its rapid integration into the supermarket supply network, which it achieved through its intense promotion of the Jaouda brand. This brand covers all kinds of dairy products, from pasteurized milk, to yoghurts and juices. As it is located more than 500 km from the main consumer centres (i.e., the large urban centres on the Atlantic coast, such as Casablanca and Rabat), Copag has had to make significant efforts to

conquer these markets through a marketing policy based on symbolic discounts (of no more than US$0.012) compared with similar products from other processors. Copag has also taken advantage of the networks of small groceries in several parts of Morocco. These are often managed by people whose origins are in the Souss Massa region, who are happy to promote the Jaouda brand among their customers.

Copag is not the only cooperative industrial dairy processor, but it is by far the most active. There are almost 30 other cooperatives in dairy processing, some of which were pioneers in the major dairy basins: Colait Extralait in the northwestern plain of the Gharb, *Le Bon Lait* in the Haouz irrigated scheme (around Marrakech), Superlait near Casablanca, Colainord in the country's north, and others. These cooperatives, including Copag, are federated into the National Union of Agricultural Dairy Cooperatives (UNCAL – *Union Nationale des Coopératives Agricoles Laitières),* which seeks to defend their interests against the *Centrale laitière* group's dominant position. However, many of these small cooperatives struggle to survive, as they face major financial difficulties and operate in small markets, with few quality brands. Together, they process no more than 20 percent of total milk volumes.

The last type of dairy chains are the informal short circuits, which are marginal and, according to the law, should not even exist. These circuits have developed near major urban centres and seem to operate with the blessing of both farmers and consumers. Farmers can sell them their milk at prices that are 15 to 20 percent higher than those from collection centres. Moreover, the pedlars who collect milk in these chains have their own vehicles and move from farm to farm, so farmers avoid delivery expenses. Another important factor is that the pedlars in these short circuits are less concerned about milk quality. As a result, suburban cattle farms can obtain significantly higher incomes from their milk output than other farms can, although suburban conditions are often difficult for dairying, owing to reduced agricultural land, pollution hazards, etc. (Sraïri and Lyoubi, 2003). These short circuit dairy chains end in small workshops, which process the milk into various traditional products and often manage small milk shops *(mahlabates)* where the dairy products are sold directly to consumers. It is worth noting that most of these *mahlabates* are situated in popular urban districts, giving low- and middle-income citizens access to typical dairy products, which are often cheaper than their industrial counterparts. Consuming in these *mahlabates* also has a symbolic social value, as friends, relatives and other people take a break together to have lunch. The *mahlabates* also sell cakes, sandwiches and fast-food, although their most important product is milk and its derivatives (in Arabic, milk is *halib* and *mahlaba* a place to get milk).

Packaging in *mahlabates* is basic, and often consists of glass bottles and recipients for milk and yoghurts, most of which are consumed on the premises. As already mentioned, the State authorities tolerate these small businesses for social and economic reasons. They are not subject to regular hygiene monitoring, so outbreaks of food-borne infections may occur.

There are no accurate data about the number of *mahlabates*, their distribution in urban centres and their activities (volumes of milk treated, gross return on sales, etc.). A typology of *mahlabates* in Morocco's largest urban centre (Casablanca, with more than 3 million inhabitants) reveals that the largest process more than 2 tonnes of raw milk a day, and the smallest only 30 to 40 litres (Letheuil, 1999). Important *mahlabates* may belong to private dairy farmers who are well-established in the city, and can process their own milk production directly. Other large *mahlabates* are managed by people who do not have dairy herds, so have to build up a network of suppliers through local pedlars. This means that *mahlabates* may collect almost the total milk output of the area immediately outside an urban centre (such as Casablanca), in circuits that depend on shared confidence among their members.

In general, whatever their size, *mahlabates* share some characteristics: milk is supplied by cattle farms through pedlars, at a mean farm-gate price of US$0.39 per litre throughout the year; and they process a range of typical products in which yoghurt *(raib*) and cheese *(jben)* are particularly important. Depending on the volume of milk it handles and its location, a *mahlabate* can provide jobs for between one and four people. *Mahlabates* may also sell raw non-pasteurized milk to households that like to process it themselves. Such raw milk is sold in plastic bags at US$0.61 per litre, which is less than the price of industrially pasteurized milk.

Because of the pace of urbanization and the progressive disappearance of traditional families, *mahlabates* are likely to continue making a significant contribution to Moroccan city dwellers' supply of dairy products, particularly low-income suburban households. *Mahlabates* are already important actors in the supply of dairy products to many Moroccan urban citizens.

Chapter 8
Discussion and conclusion

The Moroccan dairy chain has undergone some significant changes in recent decades. Having been characterized by a high level of State regulation in the 1970s, State disengagement since then has resulted in private operators becoming the most important actors in the dairy chain today. This profound change has generated important technological break-throughs, with significant impacts on dairy practices. The introduction of imported cattle breeds has allowed some farms to start specializing in dairy, implying the need for such inputs as high-quality forage and machinery, but the vast majority of farms are still dual-purpose producers of milk and meat and belong to smallholders. Increased dairying has also generated an intense collection activity, for transferring and processing milk and supplying urban centres. This has necessitated the establishment of an efficient network of milk cooperatives and a modern dairy industry, and it is an important achievement of the dairy chain that now more than 60 percent of total milk volumes are processed. Although State disengagement was somewhat sudden, leaving many farmers very vulnerable to the variability of input prices (particularly for feedstuffs), it has also encouraged the emergence of responsible private operators, who today manage all aspects of milk production, collection, processing and retailing.

Nevertheless, there are still critical bottlenecks for further development, particularly at the farm level, where the offer is highly segmented, coming from numerous farmers each producing small quantities of milk. These farms are very vulnerable to climate hazards, particularly drought, and milk output is largely dependent on rainfall levels. Many smallholder farms will therefore have to upgrade themselves or convert to other activities, to remain economically viable. A similar trend affects dairy processors, as many cooperatives operate in narrow markets with low margins (mainly for pasteurized milk).

To enhance milk productivity and quality and ensure better incomes for all the operators in the dairy chain, many challenges still need to be tackled. The most important of these is the need to increase domestic consumption, to encourage larger investments in milk production. This will not be possible unless incomes increase for low- and middle-income households. A greater demand for dairy products will also have an impact on milk quality. Industrial dairy processors will have to assume a crucial role as driving forces in the sector, as they can implement changes in milk quality standards and finance higher milk outputs (through imported heifers, milking machines, etc.). All of these developments will require highly trained animal scientists, veterinarians and managers, and training, research and development must be directed to finding solutions to the many challenges that face the dairy chain: extension of good farming practices; incentives for high-quality milk producers and processors; sound management of milk collection cooperatives; and improved water productivity from cattle farming in a context of severe water shortage.

State disengagement should be an opportunity for the State to concentrate on providing more strategic services such as supervision and planning. This could lead to the establishment of partnerships with private operators to monitor all stages of the dairy chain – the health status of herds, the quality of products, the supply to cities, research needs, etc. State authorities have already made important investments in enhancing the infrastructure (roads, electricity supply, etc.) necessary for dairy development, but higher milk outputs will require interventions on-farm, which only private operators can provide.

Finally, a balanced development of the dairy chain urgently requires a fairer distribution of the revenue it generates. This will require negotiation among all operators on such issues as milk prices and quality assessment, so that they are all remunerated according to the value of their efforts. This will create the serene business climate conducive to further investment in the dairy chain (Table 12).

As they reorient the agricultural policy to increase farm productivity and improve technological transfer to smallholder units, the State authorities are starting to consider a strategy of farm aggregation. This is a key issue in the Green Morocco plan launched in April 2008, and implies that small units will be grouped into agro-industrial chains to benefit from development. In the dairy sector, such a dynamic will rely on large farms belonging to industrial groups to help introduce agricultural innovations, such as drip irrigation, maize silage and Holstein cows, to smallholder units. There have already been some successful experiences of this, mainly involving the Copag cooperative, which is managing 14 such complexes. Each is based on a group of milk collection centres, providing the farmers who supply these

TABLE 12
Bottlenecks for future development of the dairy chain in Morocco

Problem area	Opportunity	Partners
Insufficient milk yield per cow Poor milk quality and lack of quality-based remuneration in a chain with a segmented offer	Advice to farmers on ration mixing, heat detection, etc. Introduction of farming practices that improve and allow the monitoring of milk quality	Farmers Dairy collection cooperatives Private sector State authorities (regulation)
Poorly managed milk collection cooperatives	Training of cooperative managers, and regular controls	Farmers Local elite groups Local authorities
Informal milk transformation: What status? What health hazards?	More regular controls of the safety of traditional products	State authorities Informal milk processors
Rethinking the distribution of income throughout the dairy chain	Negotiations among all operatives to ensure the supply of milk and its derivatives	Farmers Milk collection cooperatives Industrial milk processors Consumers
Increased water productivity from cattle farming	Efforts to value and save water in a context of recurrent drought	Farmers Regional authorities for agricultural development in irrigated schemes
Promoting the consumption of milk and dairy derivatives	Reconsidering nutrition policies especially for vulnerable social categories (subsidies, income increases, etc.)	State authorities Industrial milk processors Consumers' associations

centres with such inputs as advice on rations, compound feed for lactating cows and growing calves, and artificial insemination.

The revision of farm-gate milk prices according to variations in input costs and milk quality, should bring many opportunities for cattle farms, including smallholder units. This is already occurring on suburban cattle farms, which even without irrigation facilities manage to obtain comparable profitability per cow as farms in irrigated areas do. This is because the farm-gate milk price paid by pedlars supplying *mahlabates* is 15 to 20 percent higher than that in formal circuits (milk collection cooperatives). Fair value sharing throughout the dairy chain would certainly promote rural economic growth, create labour opportunities and help alleviate poverty. This must be a high priority for the Moroccan authorities if they want to ensure a sustainable dairy chain for growing numbers of consumers.

References

AFAC. 2007. *Rapport d'activités annuel*. Casblanca, *Association des Fabricants d'Aliments Composés* (AFAC). 25 pp.

Aghzar, N., Berdai, H., Bellouti, A. & Soudi, B. 2002. Groundwater nitrate pollution in Tadla (Morocco). *Revue des Sciences de l'Eau*, 15: 459–492.

Allan, J.A. 1998. Virtual water: a strategic resource – Global solutions to regional deficits. *Groundwater*, 36: 545–546.

Asri, A., Aïttaleb, A. & Duplan, J.M. 1991. La race bovine marocaine Blonde d'Oulmès Zaër. *Animal Genetic Resources Information*, 8: 60–62.

Benjelloun, S., Rogers, B.L. & Berrada, M. 1998. Income and consumption effects of milk commercialization in the Lukkos area of Morocco. *Ecology of Food and Nutrition*, 37: 269–296.

Berrada, J. 2005. *Capacity building for surveillance and control of tuberculosis*. FAO/WHO/OIE Expert and Technical Consultation. Rome, 14–16 June 2005. www.fao.org/docrep/009/a0083e/a0083e09.htm.

Centrale laitière. 2008. www.centralelaitiere.com.

Corniaux, C., Duteurtre, G., Dieye, P.N. & Poccard-Chapuis, R. 2005. Les mini-laiteries comme modèle d'organisation des filières laitières en Afrique de l'Ouest : succès et limites. *Revue d'Élevage et de Médecine vétérinaire des Pays tropicaux,* 58: 237–243.

Delgado, C.L. 2003. Rising consumption of meat and milk in developing countries has created a new food revolution. *Journal of Nutrition*, 133: 3907S–3910S.

El Ameli, L. 2005. *Les industries alimentaires au Maroc: dynamiques et perspectives de développement*. Rabat, Ministère de l'Education nationale. 464 pp.

FAO. 2006. FAO *Statistical databases*. Rome.

Hamama, A., El Hankouri, M. & El Ayadi, N. 2002. Fate of enterotoxigenic *Staphylococcus aureus* in the presence of nisin-producing *Lactococcus lactis* strain during manufacture of Jben, a Moroccan traditional fresh cheese. *International Dairy Journal*, 12: 933–938.

Hamama, A., El Marrakchi, A. & El Othmani, F. 1992. Occurrence of *Yersinia enterocolitica* in milk and dairy products in Morocco. *International Journal of Food Microbiology*, 16: 69–77.

Iglesias, A., Garrote, L., Flores, F. & Moneo, M. 2007. Challenges to manage the risk of water scarcity and climate change in the Mediterranean. *Water Resources Management*, 21: 775–788.

Kadmiri, M., Glouib, K., Verschaeve, L. & Hilali, A. 2006. Cytogenetic monitoring of domestic mammals exposed to wastewaters from the localities of Dladla and Boukallou near Settat, Morocco. *Environment International*, 32: 690–696.

Laftouhi. N.E., Vanclooster, M., Jalal, M., Witam, O., Aboufirassi, M., Bahir, M. & Persoons, E. 2003. Groundwater nitrate pollution in the Essaouira basin (Morocco). *Comptes Rendus - Géoscience*, 335: 307–317.

Le Gal, P.-Y., Oudin, E., Kuper, M., Moulin, C.-H. & Sraïri, M.T. 2007. *Rôle des coopératives dans le fonctionnement du bassin de collecte laitier du Tadla (Maroc)*. Actes de l'atelier régional du projet SIRMA. Nabeul. Tunisia. May 2007.

Letheuil, H. 1999. *La filière lait à Casablanca : approvisionnement, typologie des unités de transformation et commercialisation*. Mémoire de 3ème cycle. Montpellier, France, Centre national d'études agronomiques des régions chaudes (CNEARC). 127 pp.

Mennane, Z., Ouhssine, M., Khedid, K., & El Yachioui, M. 2007. Hygienic quality of raw cows' milk feeding from domestic waste in two regions in Morocco. *International Journal of Agriculture and Biology*, 9: 46–48.

MAAR. 1975. *Le Plan Laitier*. Rabat. 83 pp.

MAMF. 2007. *Agricultural census and production in Morocco*. Rabat. 215 pp.

Ministry of Economy and Finance. 2007. Fact sheet on the Moroccan economy. www.finances.gov.ma/portal/page?_pageid=53.1&_dad=portal&_schema=portal.

Mission Économique de l'Ambassade de France à Casablanca. 2004. *Fiche de synthèse : le marché des produits laitiers au Maroc*. www.missioneco.org/maroc/documents_news.as?/v=7_pdf_75845.

Ndambi, O.A. & Hemme, T. 2009. An economic comparison of typical dairy farming systems in South Africa, Morocco, Uganda and Cameroon. *Tropical Animal Health and Production*, 41: 979-994.

Projet Sebou. 1961. *Mise en valeur agricole de la Plaine du Gharb*. Fascicule 4, Livret 2. Rabat. 85 pp.

Ramos, J.M., Bernal, E., Esquevillas, T., Lopez-Garcia, P., Gaztambide, M.S. & Gutierrez, F. 2008. Non-imported brucellosis outbreak from unpasteurized raw milk in Moroccan immigrants in Spain. *Epidemiology and Infection*, 136: 1552–1555.

Rihani, N. & Bouslikhane, M. 2002. *Susceptibility of livestock farming systems to drought in semi-arid areas of the Mediterranean and adaptation strategies*. Main paper. 53rd Annual Meeting of the European Association for Animal Production. Cairo.

Sraïri, M.T. & Baqasse, M. 2000. Evaluation du devenir et des performances de génisses laitières frisonnes importées au Maroc. *Livestock Research for Rural Development*, 12: 3. www.cipav.org.co /lrrd/lrrd12/3/sra123.htm.

Sraïri, M.T. & Chohin-Kuper A. 2007. Conséquences de la libéralisation des marchés sur les opérateurs de la filière laitière au Maroc. *Revue d'Élevage et de Médecine vétérinaire des Pays tropicaux*, 60: 177-187.

Sraïri, M.T. & El Khattabi, M. 2001. Évaluation économique et technique de la production laitière intensive en zone semi-aride au Maroc. *Cahiers Agricultures*. 10: 51–56. www.john-libbey-eurotext.fr/articles/agr/10/1/51-5/index.htm.

Sraïri, M.T. & Faye, B. 2004. Pratiques d'élevage de bovins laitiers considérées à l'aune du discours technique: quelques exemples à partir du Maroc. *Ethnozootechnie*, 74: 47–58.

Sraïri, M.T. & Kessab, B. 1998. Performances et modalités de production laitière dans six étables spécialisées au Maroc. *INRA Productions Animales*, 11: 299–304. www.inra.fr/Internet/Produits/PA/an1998/num984/srairi/mts984.htm.

Sraïri, M.T., Lahyani, A. & Lyoubi, R. 2006. Dairy cattle management practices and performances in a suburban region in Morocco. *Al Awamia*, 118/119: 155–168. www.inra.org.ma/ist/publications/awamia/awamia118119.pdf.

Sraïri, M.T., Leblond, J.M. & Bourbouze, A. 2003. Production de lait et/ou de viande: diversité des stratégies des éleveurs de bovins dans le périmètre irrigué du Gharb au Maroc. *Revue d'Élevage et de Médecine vétérinaire des Pays tropicaux*, 56: 177–186.

Sraïri, M.T. & Lyoubi, R. 2003. Typology of dairy farming systems in Rabat suburban region. Morocco. *Archivos de Zootecnia,* 52: 47–58. www.uco.es/organiza/servicios/publica/az/php/img/web/30_10_32_05srairi.pdf.

Sraïri, M.T. & Medkouri, H. 1999. Production et écoulement du lait en région d'agriculture pluviale au Maroc. *Tropicultura,* 16/17: 321–326.

Sraïri, M.T., Ben Salem, M., Bourbouze, A., Elloumi, M., Faye, B., Madani, T. & Yakhlef, H. 2007. Analyse comparée de la dynamique de la production laitière dans les pays du Maghreb. *Cahiers Agricultures*, 16: 251–257. www.jle.com/fr/revues/agro_biotech/agr/e-docs/00/04/33/97/article.md?type=texte.html.

Sraïri, M.T., Touzani, I., Kuper, M. & Le Gal P.-Y. 2008. Valorisation de l'eau d'irrigation par la production bovine laitière dans un périmètre de grande hydraulique au Maroc. *Cahiers Agricultures*, 17 : 271–279.

Sraïri, M.T., Benhouda, H., Kuper, M. & Le Gal, P.-Y. 2009a. Effect of cattle management practices on raw milk quality on farms operating in a two stage dairy chain. *Tropical Animal Health and Production*, 41: 259-272.

Sraïri, M.T., Kiade, N., Lyoubi, R., Messad, S. & Faye, B. 2009b. A comparison of dairy cattle systems in an irrigated perimeter and in a suburban region: case study from Morocco. *Tropical Animal Health and Production*, 41: 259–272.

Sraïri, M.T., Rjafallah, M., Kuper, M. & Le Gal, P.-Y. 2009c. Water productivity through dual purpose cattle (milk and meat) herds in the Tadla Irrigation Scheme, Morocco. *Irrigation and Drainage*, 58: 334-345.

Tarrier, M. 2003. Les papillons, mémoire vive du Maroc. www.ctv.es/users/tarrier/tarrier_m/index.htm.

Vaysse, J. 1952. *L'élevage au Maroc, 35 années d'expérience zootechnique et de protection du cheptel, vol. 1, Ruminant*s. Rabat, La Terre Marocaine. 326 pp.

Zaida, F., Chadrame, S., Sedki, A., Lekouch, N., Bureau, F., Arhan, P. & Bougle, D. 2007. Lead and aluminium levels in infants' hair, diet and the local environment in the Moroccan city of Marrakech. *Science of the Total Environment*, 377: 152–158.

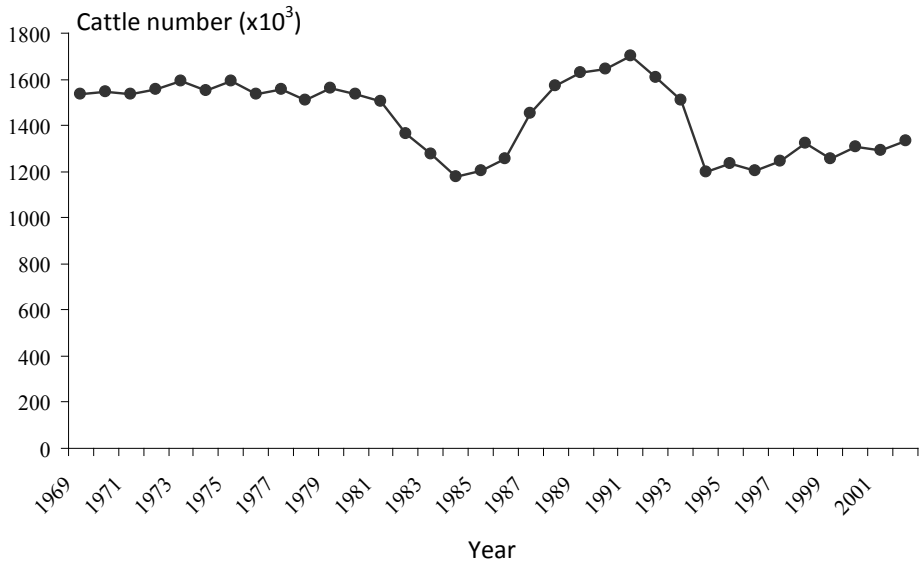
Annex 1

The main irrigated areas in Morocco

PID = Doukkala irrigation scheme (104 600 ha), 14.5 percent of milk production; PIGL = Gharb/Loukkos irrigation scheme (132 000 ha), 12.5 percent; PIH = Haouz irrigation scheme (142 000 ha), 16.0 percent; PIM = Moulouya irrigation scheme (77 000 ha), 3 percent; PIO = oasian irrigation schemes (65 000 ha), 1.5 percent; PIS-M: Souss Massa irrigation scheme (40 000 ha), 6 percent; PIT: Tadla irrigation scheme (109 000 ha), 14 percent.

Annex 2

Evolution of the number of reproductive cows in Morocco



Source: MAMF, 2007.