The Dairy Livestock Value Chain in North Africa, Status and Perspectives within the scope of LiDeSA

Acronym: LIVE2AFRICA

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Abstract: Dairy cattle and buffalo value chains are sources of income and employment for small holders in North Africa. The region, with more than 209 million consumers, still depends on importation of milk and breeding stocks. The objectives were to 1) describe the status of the Dairy Livestock Value Chains (DLVCs) in North Africa, and, 2) identify potential pathways for their future empowerment and sustainability. Data came from the AU-IBAR North Africa country reports on the Assessment of the National Breeding Objectives and Implementation of Supporting Programs for DLVCs. Main results showed that milk powder value chain represents 60% of the milk processed in Algeria. The traditional type where milk is produced locally, auto consumed and distributed with little industrial transformation, is met in rural and peri-urban communities of large cities of the region. The organized DLVC-type is met in Morocco and Tunisia with more than 70% of milk collected and processed through organized channels. Small holders in the region, with less than 5-10 cows, are responsible for 90 % of the milk produced. The described status of the DLVCs in North Africa helped define catalytic actions, based on breeding strategies, as perspectives for their sustainable development within the scope of Live2Africa.

Keywords: Dairy, Cattle, Buffalo, Chain, Milk, Africa, Breeding, Cheese, Yogurt, sustainability

1. Introduction

Developing countries have recognized, since the last few decades, a rapid transformation in their traditional livelihoods dictated by urbanization, better incomes and improvement of standards of living. These dynamics, enhanced by a relatively high demographic increase, have led to a massive demand of products from animal origin mainly meat, eggs and milk. The increase of the combined per capita consumption of the latter three animal products in developing countries grew approximately by 50 percent in a twenty years period since the seventies [1]. Faced with poor producing abilities of their native livestock breeds, the majority of developing countries chose to import high yielding exotic breeds to reduce their dependence on livestock products imports. This is the case of poultry and dairy cattle. While multinational companies are dominating the world market for the poultry sector, the dairy cattle international market is still opened to many bull studs, Artificial Insemination Centers (AI) and heifers' private businesses. The dairy livestock sector shows, today, two contradicting situations worldwide or production models. The first situation characterizes developed countries that recorded high productivity levels in milk production, while their animal populations have decreased. This is the case of North America and Europe (figure 1) [2].

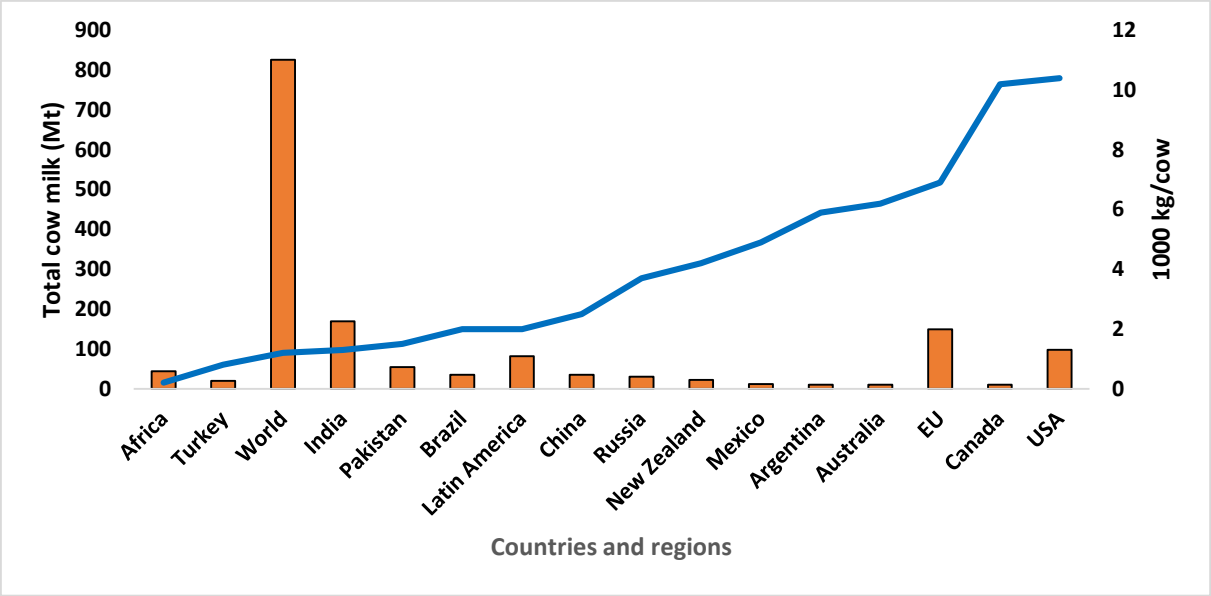

Figure 1. Total cow milk and cow milk yield in selected countries and regions

On the other hand, developing countries are still struggling to produce milk by increasing their animal numbers to meet their massive populations demand in milk and milk derivatives. The highest percentages increase in inventories are found in India, Pakistan and Africa [2]. Africa is the continent where the highest percentages of severe food security and moderate food insecurity are recorded, representing more than half of 687.8 Million hungry people reported in the world [3]. Being aware of the roles played by livestock in Africa, a Livestock Development Strategy for Africa (LiDeSA:2015-2035) was approved and endorsed by the African Union Heads of State and Government in January 2015 [4]. One of its objectives was to enhance innovation and capacity building of value chain actors through a value chain approach. The AU-International Bureau for Animal Resources (AU-IBAR) developed the Live2Africa 5-year project as a concrete contribution to the implementation of LiDeSA. The project aimed to build systemic capacity building in seven thematic areas including catalyzing commercialization and transformation of Africa's Livestock Value Chains (LVCs). The objectives of this article were to: 1) describe the Status of the Dairy Livestock Value Chain in North Africa and 2) present its Perspectives within the Livestock Development Strategy for Africa (LiDeSA).

Methodology

Information used in this case report came from a synthesis work of various workshops and consultations conducted by the AU-IBAR [4-7]. The "Livestock Value Chain Prioritization" workshop was held in Nairobi, Kenya on February 2019 in order to identify three LVCs priorities for each of the 5 regions of the continent. The workshop was attended by a variety of participants representing operators from international, regional and national livestock value chains. North Africa region including six countries (Algeria, Egypt, Libya Mauritania, Morocco and Tunisia), through their livestock value chains SWOT analysis, retained Livestock Dairy Value Chains as their first priority. AU-IBAR launched regional consultancies in August 2020 to prepare a regional report on the Assessment of the National Breeding Objectives and Implementation of Supporting Programs for Dairy Livestock Values Chains (DLVCs) in North Africa. Agreed on guidelines were used to have a harmonized data base and structure for national

country reports. A special focus was put, in this work, on the assessment of the Base-Line status of the Dairy Livestock Value Chains and the assessment of the Breeding Strategies within the National selected DLVC. Specificities of Dairy Livestock Value Chains in North Africa were identified and assessed at its various segments from production to marketing. A special focus was put on breeding strategies to improve dairy bovine milk productivity, with proposed catalytic actions to boost the DLVC in North Africa.

2. North Africa: Population, land, climate and agriculture

North Africa region (Algeria, Egypt, Libya, Mauritania, Morocco and Tunisia) specific indicators in human populations, land areas and the contribution of agriculture to countries' economies are in table 1. The region has 209.9 million people [8]. Egypt, with its 104 million people, is the most populous country in the Arab World and the third most populous on the African continent after Nigeria and Ethiopia. Algeria and Morocco have 45 million and 37 million people, respectively. Countries with less population in the region are Tunisia, Libya and Mauritania with 11.9 million, 7 million and 4.8 million people, respectively [8]. North Africa total land area covers more than 678 million ha, representing 5% of the world landmass of which only 16% is arable. The ratio of arable land/agricultural area shows that Egypt has the highest ratio (76%) followed by Tunisia (27%), Morocco (23%) and Algeria (18%). Libya and Mauritania have 11% and 1%, respectively. Egypt has the highest potential of irrigation in the whole region (100 %), with a high level of intensification. Agriculture, in the remaining North Africa countries, is highly dependent on climate conditions and rainfall. Potential of irrigation of the cultivated land is approximately 15% for Algeria and Morocco and 9% for Tunisia. The contribution of agriculture of the region in national GDPs varies from 2% in Libya to 19% in Mauritania. The remaining countries show 12% on average (Table 1).

Table 1. Approximate Human populations, land areas and agriculture in GDP in North Africa.

Country	Population[1] (million)	Urban (%)	Total[2] area (a) (1000 ha)	Agricultural[2] area (1000 ha)	Arable land[2] (100 ha) (b)	b/a %	Agriculture in GDP[3] (%)
Algeria	44.6	74	238174	41359	7505	18	12.38
Egypt	104.3	43	100145	3836	2911	76	11.09
Libya	7	81	175954	15350	1720	11	1.85 (2008)
Mauritania	4.8	55	103070	39661	400	1	18.70
Morocco	37.3	64	44655	29612	6899	23	12.16
Tunisia	11.9	70	16361	9743	2607	27	10.27
Total	**209.9**		**678359**	**139561**	**22042**	**16**	

[1][6]; [2] [3]; [3][5]

Limited arable areas, limited water resources, aridity and climate change constitute real threats to agriculture in North Africa, in general, and to the livestock dairy sector, in particular. If the option to produce milk by increasing the dairy cattle population's sizes continues, as followed since the seventies, the region will face difficulties, given its limited forage and water resources. Policy makers should be aware of the importance improving livestock productivity per animal, even under difficult environmental conditions that characterize the region. Given that natural resources are limited and animal feed costs are becoming volatile, developing countries are invited to understand the usefulness of the "productivity model". Livestock productivity is an essential multifunctional technical, economic and environmental indicator that describes the efficiency of livestock sectors in general. It translates the efficiency of livestock management and practices to produce more output per animal and, consequently, feed and health costs will

be reduced by culling poor producing animals. Based on productivity, farmers produce enough with less animals leading to less gas emissions and less natural resources degradation allowing to combat climate changes negative effects. It is now shown that the world milk production is coming mainly from cow milk (81%), 15% of buffalo milk, and 4% for goat, sheep and camel milk combined [9].This is a proof that dairy cattle are essential worldwide in milk production compared to all other animal species combined.

3. North Africa: Dairy cattle production systems, species and breeds

The region is a reservoir of a diversity of species and breeds [10-12]. There are more than 72 million heads of sheep, 26 million heads of goats, 12 million heads of cattle, 3 million heads of dromedaries (the number of dromedaries in Tunisia is for females), and almost more than 3 million heads of buffalo (Table 2) [12-15]. Egypt is the only country in North Africa region with more than 3 million heads of Buffalo. Buffaloes were introduced in Egypt during the 7th Century [16].

Table 2. North Africa Region's Livestock in 1000 heads/species

Country	Cattle	Buffalo	Sheep	Goats	Dromedaries
Algeria	2000		27000	5000	35
Egypt	4387	3433	1760	3974	156
Libya	185		5305	1900	66
Mauritania	1900		11040	7510	1496
Morocco	3500		20600	6500	250
Tunisia	759		7000	1500	70*
Total	**12731**	**3433**	**72705**	**26384**	**2073**

*Females

Livestock is an essential component of the region economy with various roles played at social, cultural and employment levels. Trends of cattle populations in North Africa region since 1970 are shown in figure 2, [12]. Egypt comes first with the highest cow population in the region (5 million head), followed by Morocco (3 million head). Algeria and Mauritania have similar cattle population sizes (2 million head) and both Tunisia and Libya with approximately one million, combined.

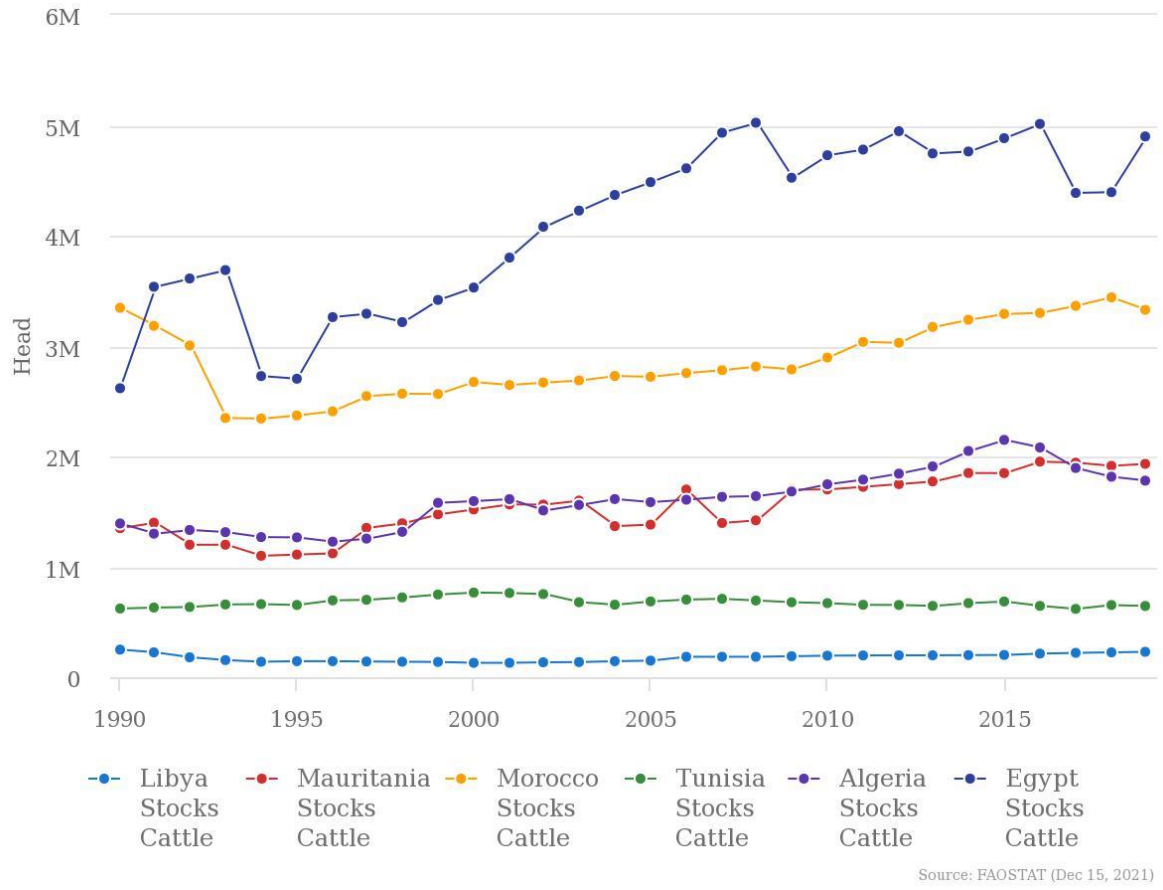

Figure 2. Cattle populations trends in North Africa

Production systems and cattle breeds in North Africa have known, since the seventies, a dynamic change leading to the actual situation where imported specialized exotic dairy cattle breeds and their crosses with native bovine have substituted a high percentage of native cattle. Native breeds are drastically decreasing, during last decades, from over 95% in the seventies to less than 43%, on average, in 2020 [13-14]. Imported exotic breeds are raised, in general, under favorable irrigated environments. Exotic-native crosses are encountered in rain fed areas and native cattle are left in the low input (extensive) production systems. In Morocco, 40% of the dairy cattle are raised in intensive production systems of which 71% are in irrigated areas. The irrigated land occupies 1.6 million ha and supplies more than 82% of the produced milk. The main dairy breeds encountered are Holstein Friesians, Montbéliarde and Fleckvieh. The rain fed agricultural areas are home to 45% of dairy farms with exotic-native crossbred cattle. The system relies more on agro-industry by products feeding and less forages. The extensive cattle system is met in marginal areas (arid, semi-arid and mountains) where the majority of native cattle breeds are raised traditionally under pastoral feeding. This is a real case where the genetic makeup of the national cattle population has changed from native to exotics and exotic crosses in order to satisfy a high local demand in milk and milk derivatives. The lack of reliable breeding strategies for native cattle and their continuous upgrading to exotic breeds is still leading to the loss of very valuable native cattle genetic resources. The latter are known for their good adaptive traits to high temperatures and harsh environmental conditions. The Tunisian experience in dairy cattle is similar to the Moroccan one. It goes back to the 1970s when Tunisia formed a first nucleus of herds of Friesian cows imported from Holland. The national cattle population was, at that time, 407,000 cows, 93% of which were of the autochthonous type with

low milk production abilities. Tunisia therefore had a significant milk deficit and depended on the import of powdered milk to meet its local demand for milk and milk derivatives. Fifty years later, following government and privatization initiatives in the dairy industries, the situation has changed where the cattle herd, with a total number of 401,000 cows, has undergone a transformation in its composition with 58% purebred cows with Holstein dominance and 42% native-crossbred cows [15]. In Northern Tunisia, known for its favorable environmental conditions with possible irrigations, most of the herds (78%) are raised. The remaining herds (22%) are located in central regions with semi-arid environmental conditions. In these areas, "landless" livestock production systems predominate and concentrated feeds partly supplement basic feed rations (hay, straw, cacti) [15]. State farms, coops and large private farms has approximately 4% of the national dairy herd cows. The remaining 96 % belong to small holders with less than 5-10 cows. The dramatic increase of feed costs is putting more pressure on peri-urban dairy activities and landless dairy operations and, consequently, on their sustainability. In Egypt, the dairy livestock sector relies on both cattle and buffalo, which are two major species in the country contributing to milk production [17].

Egypt has invested, like Morocco and Tunisia, in importing good quality breeding stocks from abroad (heifers and semen). Unfortunately, native cattle (Baladi) have suffered greatly from the introduction of exotic breeds due to indiscriminate crossing. From1991 to 2004, Baladi cattle have lost 19% of their share in the national cattle herd and it is difficult to find pure Baladi cattle except in some few research centers [18]. The number of buffalo and cow females increased, respectively, from 670 thousand and 580 thousand in the sixties to more than 1.9 million and 1.7 million for buffalo and cattle, respectively. Buffaloes increased by 10%, Exotic cows increased by 40%, native cows decreased by 6% and crossbred cows increased by 210% [19-20]. Both cattle and buffalo are integrated with crop production. This is due to the limited natural pastures in the country. Intensive large herds represent 7% and semi-intensive medium herds production systems represent 60%. The low input production system is home of native cattle and buffalo (33%) [13, 19-20].

If Egypt has the specificity of the coexistence of dairy cattle and buffalo in producing milk with almost the same total amount of milk, Mauritania has the specificity of the existence of only native cattle with no exotic breeds. It has also the specificity that milk comes from three different species: cattle (44%), dromedaries (33%) and goats (23%) [21]. The bulk of the livestock diet is coming from pastoral areas. The most important pastoral potentialities are found in the East of the country, where two thirds of the exploitable areas are concentrated, the rest being distributed between the Center and South (river area) of the country.

Even though North Africa region is home of a diversity of animal species and native breeds, purebred dairy cattle (mainly exotics) are met in most favorable areas where forages are usually grown. Native crosses with exotics are raised in rain fed areas, and native cattle are left in marginal and mountain areas. This translates that cattle breeds are evaluated on their differences, while neglecting the importance of the variability of milk yield within breeds. Policy decisions, made 40 years ago, to provide milk to a growing population, through imported exotic breeds, have resulted into a continuous dependence on outside imports of milk powder, semen and dairy heifers. The main exotic cattle breeds imported are mainly Holsteins with other few breeds like Brow Swiss, Tarentaise, Fleckvieh and Montbéliarde. This trend is real until today and it continues showing a native bovine biodiversity loss, even though total milk production is improving. Figure 4, [12].

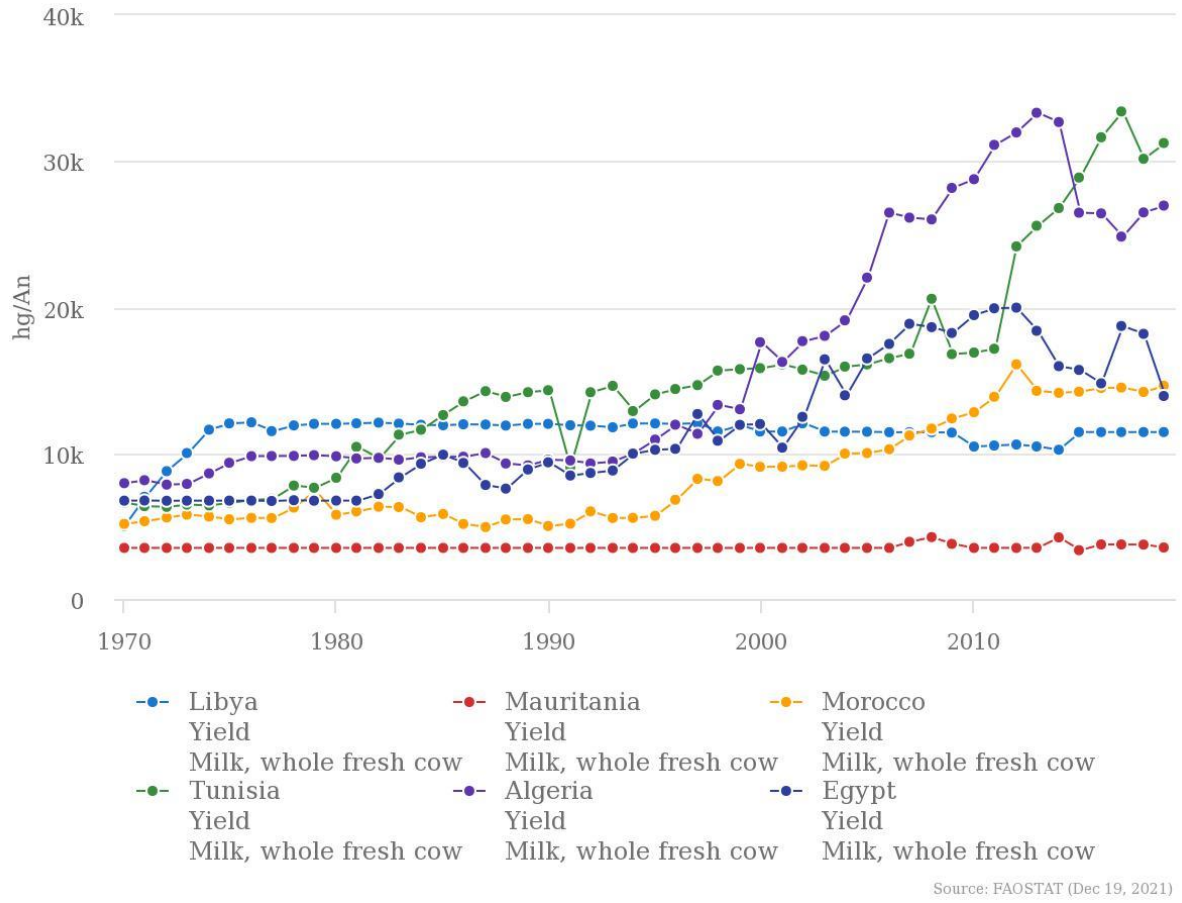

Figure 4. Trends in dairy cattle milk yields by country

Exception made for Mauritania, countries of the region witnessed an increase in milk yield per cow compared to the seventies. The increase of cows of exotic breeds at the expense of native ones is translated with an increase of milk yield observed. Tunisia and Egypt recorded the highest increase, followed by Algeria and Morocco. Mauritania remained with the lowest yield/cow. Mauritania chose to continue with native cattle but failed to invest in reliable breeding strategies to improve native cattle milk productivity [21].

4. Status of the Dairy Livestock Value Chain in North Africa

Three mega Dairy Livestock Value Chain- types, based on milk production, collecting milk, processing of milk and marketing of milk and milk derivatives, can describe the dominant Milk Value Chains in the region (Table 3). The first DLVC type is based on imported milk powder. This type, characterized by milk powder processing and distribution levels, is still dominant in Algeria and represents 60% of the milk processed in the country. The country is now encouraging local milk production through importation of dairy cattle and incentives to shift into producing milk locally and reduce their dependence on milk powder imports. The second type of Milk Value Chain, where milk is produced locally, auto consumed and distributed with little industrial transformation, is met in Mauritania and peri-urban communities of large cities in the region, like in Egypt. The third type, which is the full DLVC-type with Production, Collection, Processing and Distribution levels, is met in Morocco and Tunisia with more than 70% of milk collected and processed through organized channels. Milk Collecting Centers are playing key roles in this full DLVC-type where small holders, with less than 10 cows, are responsible for 90 % of the milk produced (Table 3).

Table 3. Summary of basic DLVCs in North Africa Region [13-15,21].

Country	Percent contribution in milk in the country						Self-consumption and traditional process	Milk colleting and processing through Organized channels	Average milk consumption /capita/year (kg)	Dairy producers (1000)	Small holders <= 10 cows %
	Cattle	Buffalo	Goats	Sheep	Dromedary	Imported Milk Powder					
Algeria	**40**					**60**	15	25	143	Na	na
Egypt	**56**	**44**					80	20	59[a]	62 000	**90**
Libya	**na**								Na	170	**Na**
Mauritania	**44**		**23**	3	**31**		72	4	168	Na	**Na**
Morocco	**96**		2		2		20	80	74	260	**90**
Tunisia	**96**		1	2	1		30	70	117	112	**94**

The actual status of the DLVCs in the region shows specific characteristics. Small holders, representing 90% of dairy bovine producers, are playing the main socio-economic roles in North Africa livestock dairy sector. Algeria imports 60 % of its national needs in milk as milk powder. Egypt produces its milk by two bovine species dairy cattle and buffalo (56% cattle and 44% buffalo). Mauritania relies on three species, native cattle (44%), dromedaries (31%) and goats (23%) to produce milk. Tunisia and Morocco show an advanced status in milk collecting and processing through organized channels. However, the Milk Value Chains are still traditional, in the region, with a majority of consumers dependent on unpasteurized milk. The traditional main dairy value chains still include different interacting actors with many intermediaries. The latter's role depends on demand of consumers according to season and market prices. Existing modern or quality controlled dairy value chains are under official quality and sanitary control. The two types of dairy value chains, sometimes, meet together when the need is expressed to secure their milk supplies [13-15, 21]. The DLVCs situation translates that there is room for improvement in the future to upgrade its different levels and reduce the milk quality gap. Therefore, dynamic and catalytic transformations are required to upgrade existing types of DLVCs and produce good quality milk to consumers, while securing descent incomes to stakeholders, mainly small holders. Such an option is well justified, given that the livestock dairy value chain was selected, by the region, as the first livestock priority in North Africa region [4].

4.1. Status of the DLVC at the production level

4.1.1. Production systems and breeds

Favorable production systems in North Africa region are, in general, reserved to exotic high yielding breeds with their native crosses placed in semi-intensive production systems. Native breeds are raised in low input harsh environments. The rising of feed costs, in comparison to milk prices since the last decade, is putting a high pressure on small farmers to secure descent revenues. Milk produced by cow/lactation varies between herds within countries and among countries. In Morocco, the average milk production under the milk recording system is about 4,000 kg/purebred cow/lactation and 2,100 kg/crossed cow/lactation. There is a wide variation among dairy farms. In large specialized farms, the average level of production is 9,700 kg/cow/per lactation [14]; the majority are struggling to exceed 3,000 kg. In Tunisia, in 2020, average milk yield was 5944 kg/cow/lactation in the recorded herds and estimated to be 1263 liters for crossbred and 643 liters for native cows [15]. Age at first calving was on average 33 months and calving intervals were 455 days on average. Culling rates were 29% [23]. Summer calving frequencies are still high during hot months of July and August, compared to favorable seasons for dairy cows calving in Tunisia [24]. These results translate that improvement of dairy cattle production does exist by reducing first age at calving, calving intervals, culling rates and increasing frequencies of calving in favorable months. Average annual milk yields varied, in

Egypt, from 3000 to 4000 kg/cow in medium production systems. They were lower than 2000 kg/cow in lower input production systems. Milk yield production was estimated at around 2000 liters/head for dairy cows and 1500 for buffaloes [19]. As reported by [19]. four major farming systems were identified in Egypt, the "urban and peri-urban, the old lands of the Nile Valley and the newly reclaimed lands in the West Delta". Dairy farms in the first two farming systems are oriented to milk market. Family farms in the old land are oriented to butter and cheese.

There is no doubt that cow genotype is changing in the region from native ecotypes or populations, known for their good adaptation to harsh environments and their poor producing ability in milk, toward exotic genotypes mainly Holsteins and little presence of Brown Swiss, Tarentaise and Montbéliarde. A large increase of native-exotic crosses was observed as a result of indiscriminate and uncontrolled upgrading, accelerated by the use of AI. Policy makers should be aware of the continuous loss of native cattle in the whole region. These native breeds contain valuable genes in them to adapt to climate change negative effects. They should be aware that coherent crossbreeding strategies do exist to improve native cattle by using exotic genes without going to a complete upgrading process, caused by uncontrolled cross breeding. Buffaloes, in Egypt, are major contributors of milk and cheese. Their high milk quality and their adaptation to roughage feeds allow them to be very competitive compared to exotic dairy cattle. In Mauritania, even though dromedaries and goats are contribution to the national milk production, it is wise to invest in reliable breeding strategies to improve dairy cattle milk production.

4.1.2. Type of farmers, herd size and milk recording

A large number of small holders characterizes, in general, North Africa dairy livestock sector. Small farms with less than 10 cows exceed 90% of total cattle owners. In Egypt, more than 1.8 million households raise more than 2.41 million and 2.96 million of buffalo and cattle females, respectively, out of approximately 6 million households keeping livestock. Small dairy bovine holders represent 90% and households with less than 2 cows represent 78%. Only 0.8 % of buffalo females and 18 % cows are identified [13]. In Morocco, the total number of dairy cows was estimated to be 1.2 million belonging to 1.8 million farmers. Identified cows, up to 2017, reached 738,000 cows. Farmers participation to milk recording represent 5% with 60,000 cows in 650 farms [14]. In Tunisia, there are 112,000 dairy producing farms. They have, on average, between 2-3 cows and 94% of the smallholder farmers have less than 10 cows. According to official statistics of the Tunisian MOA [23], the number of cows enrolled in the National Milk Recording System is actually 13,000 out of 248,000 purebred cows. Approximately 7000 cows belong to State, Coops and Private enterprises. The remaining 6000 cows belong to private owners. In 2020, the number of herds enrolled in national milk recording system was 582 herds [23-24]. The remaining countries lack national official milk recording programs similar to Morocco and Tunisia. Policy makers should be aware of the importance of animal identification, performance recording as valuable sources of information to better manage and improve dairy cattle productivity. They should be aware of small holders' roles as key stakeholders in the national dairy sector. Therefore, their empowerment, through farmers' organizations, suitable extension and milk value chains catalytic activities, is an essential strategic orientation.

4.1.3. Heifers and bull semen imports

North Africa region is still dependent on bull semen and purebred heifers' importation due to the increase demand of the dairy sector and the incapacity, at national levels, to satisfy farmers' demands in good quality breeding stocks. During the period 1980-2000, Egypt has imported

1,250,000 and 974,000 heifers of buffalo and cattle, respectively. The last two decades, Egypt has imported 2,995,000 and 2,653,000 of buffalo and cattle, respectively [13].

In Morocco, the massive imports of heifers began as early as the 1970s in order to increase national milk production and build up a national herd of high milk producing cows. The increase of imports has been gradual and regular, and each time set thresholds have been exceeded with a peak in 1996 of 37,255 heifers. In 2010, imports of heifers reached 26,737 heifers and in 2018, imports reached 21,000 heifers [14]. Imports of specialized dairy cows of Holstein, Montbéliarde and Fleckvieh breeds have affected the genetic structure of Moroccan cattle herds' structure. The import of frozen semen is regular in general. The trend has been increasing in recent years to reach about 626,118,000 doses in 2018 [14]. It is important to note that the dairy sector in Morocco remains genetically very dependent on imports of heifers and frozen semen from abroad. Morocco started to produce pure dairy heifers since 1986 to meet the growing demand of breeders for replacements and to reduce the bill for heifer imports reaching, on average, US$ 3000/imported heifer. The total number of heifers produced at the national level was 6,356 heads during 1980–2000 and increased to be 59,532 heads during the period 2000.2018 [14]. This production remains insufficient, indicating the low production of heifers to ensure the renewal of dairy cows from local production due particularly to low participation of breeders to milk recording despite all the efforts undertaken in this framework since 1986, as reported in [14]. For semen production, the total number of doses produced by the two existing AI Centers was 2,621,118 doses for the period 2009–2016. The average annual production was 327,640 doses ranging from 106,197 doses in 2010 to 920,283 in 2013 [14]. This production remains, however, low and cannot meet the high needs of Moroccan dairy farmers who rely on imported semen.

In Tunisia, local semen production reached, in 2020, 123,000 straws (26% Holsteins, 35% Brown Swiss, 21% Tarentaise, and 16% Montbéliarde) [15]. The local semen produced covers only 1/3 of the national dairy cattle needs. Around 200,000-300,000 straws are imported annually with more than 80% Holsteins. The rate of the annual increase of dairy heifers produced locally in Tunisia is approximately +1.6% during the period 2013-2020. It increased from 23,000 heifers in 2013 to 25,000 heifers in 2020 [15]. Tunisia has imported more than 4000 heifers during the period 2013-2020 from Europe with an approximate price ranging between US$ 2000-3000/pregnant heifer.

The actual status of North Africa DLVCs shows, at the production level, the existence of a potential germplasm of purebred cattle raised in favorable environment areas. This situation offers a possibility to implement a national and a regional strategy to produce good quality breeding stocks for the dairy sector in the region. Farmer organizations, animal identification and milk recording systems are essential ingredients needed for dairy bovine genetic improvement in North Africa. They constitute concrete catalytic actions to empower the DLVC at the production level including smallholders, as they appear to be the weakest stakeholders within the actual DLVC framework. The lack of farmers' organization and the lack of coherent and complete recording systems and genetic evaluation tools translate the incapacity of the region to produce enough breeding stocks with known breeding values to enhance herds productiviy.

4.2. Status of the DLVC at the Collecting level

North Africa region shows a variety of situations at the DLVCs milk collecting level. The two countries in the region, where well-established Milk Collecting Centers (MCC) exist, are Morocco and Tunisia. In Morocco, there are around 2,700 Milk Collecting Centers divided into 1,900 cooperatives' MCC and 800 MCC directly linked to large dairy farms and private operators [14]. The formal and organized circuit, which represents around 80% of the volume of milk collected, is organized through a network of big cooperatives like COPAG and private industrial operators like Danone. Milk produced at the farm level or collected in MCC is transported to processing factories for high-quality milk and milk derivatives. The informal circuit (20%) is organized around several intermediates who collect milk directly from farms and even cooperatives. This informal milk is often sold as raw milk to "Mahlabats" where it's processed into traditional products, or even sold directly to cafes and households. The informal circuit involves various operators that are active mainly in the dairy basins near large urban centers.

In Tunisia, a dairy surplus in fluid milk was reached in 1999 [15]. In 2017, the country has more than 200 Milk Collecting Centers with a capacity exceeding 2.8 million liters/day. They collect approximately 900 million liters, from small farmers, representing 63% of the milk produced in the country. Hawkers collect the rest, they transport milk either to collection centers or processors or even to wholesalers. This type of operator is benefitting from the lack of organization in the Dairy Value Chains. The introduction of a health certification process for collecting centers and dairy processing units was a major step forward for the Tunisian milk sector and for protecting consumer health [15].

In Egypt, the milk sector is still traditional and represents the majority of the country milk consumers (80%) mainly urban and peri-urban. The pattern of established dairy collection points has become common in most villages since mid-nineties. Each point belongs to a merchant broker, who works for a wholesaler that, in turn, deals with several other collection points to collect milk from several villages. Before mid-twenties, buffalo milk dominates fresh milk [13, 19]. Since 2005, there has been a special focus on pasteurized milk in Egypt mainly with large dairy cow farms. At the milk collecting level, policy makers should be aware of the importance to upgrade the milk collecting system in order to insure milk quality and secure the health of consumers. A special focus is needed at this level in investments in milk cooling, milk transportation and pasteurization as well as in legislation and extension services.

4.3. Status of the DLVC at the transformation level

Even though Egypt dairy sector is in its majority traditional, it was reported that Egypt was 37th cow milk producer and the 4th buffalo milk producer in the world in 2011/12 [19]. In the Mediterranean region, Egypt was the third producer of cheese after France and Italy [19]. In rural areas, the majority of cheese is homemade especially the fermented salty cheese. The country is witnessing a trend toward a remarkable emergence of family businesses and private cheese factories.

In Morocco, the industrial operators in charge of milk processing include private stakeholders like the multinational Central Danone and large cooperatives (COPAG) and "Domaines Agricoles". These influencing stakeholders have largely diversified their production and they have a national and international dimension. They export their milk derivative products abroad with added economic value. Morocco Green Plan (MGP) strategy restructured in 2009 the Dairy

cattle sector by creating a national Inter-Professional Milk Federation (FIMALAIT). This Federation includes representatives of dairy producers organized at upstream level into a National Federation of Milk Producers (FENEPROL) and representatives organized at downstream by bringing together processors and industrials in the National Dairy Industry Federation (FNIL). In 2019, the dairy sector underwent organizational changes so that FIMALAIT became MAROCLAIT, FNEPROL became FEMAPROL and FNIL became FMIL with almost the same stakeholders [14]. These new organizations of actors constitute a strong network and can actively participate in public policy dialogue. They can also influence domestic markets, milk prices and be able to negotiate local public investment, as well as social services for their members. In general, the large professional organizations provide a large list of services to milk producers and dairy cattle breeders (veterinary services, genetic improvement (Artificial Insemination, Milk Recording, and imports of heifers and semen), transports of production, milk collecting, storage, feed supply, training and other facilities). The inter-professional organization (MAROCLAIT) also has a main role of supporting milk subsector and increasing its competitiveness. The MAROCLAIT is also a member of the Moroccan Confederation for Rural Development (COMADER), which includes 19 other agricultural inter-professional federations.

In Tunisia, the inter-professional group of red meat and milk (GIVLAIT) regulates the dairy value chain. The GIVLait is a legal entity of public and economic interest, endowed with a financial autonomy under the supervision of the Ministry of Agriculture. For the dairy sector, the GIVLait insures the storage program for fresh sterilized milk, strengthen the sale of powdered milk, export of the sterilized milk and supports Milk Collecting Centers [25]. Even though some forms of organization exist, large companies leaving little power to small producers at the production level dominate the dairy sector . Policy makers should be aware of the importance of the involvement of small holders in professional organizations as well as the impact of short milk value chains in empowering DLVCs in the region. The national processing capacity is reaching 5.7 million liters/day. The processed milk quantities increased from 850 million liters in 2013 to 1.211 billion liters in 2020 with an annual growth rate of 6% [15]. In 2017, there was reported 45 milk companies of different sizes and ownerships, processing a total of 5620 thousand liter/day [15]. These companies processed fluid milk (11 companies), milk powder (2), cheese (25) and yogurt (9). The Delice Danone operator represents 50% and 70% of the overall drinking milk and yogurt shares in Tunisia. Two other groups, with limited market shares (Vitalait and Laino) are active in milk and yogurts. In cheese making the "Centrale des Produits Laitiers" represents 60% of the total cheese production in the country [15].

4.4.Status of the DLVC at the distribution and market levels

Egyptian cheese goes back to 2000 BC, as shown in Egyptian murals tombs, and cheese, yogurt and rice remain essential ingredients in the Egyptian diet [19]. There are, in Egypt, four categories of cheese: the hard cheese, the white cheese made from fresh cow or buffalo milk or a mixture of the two, Feta cheese and Karish cheese out of skimmed milk [19]. Egypt has a variety of dairy products in milk, yogurt and processed cheese. The milk consumption (excluding butter) in Egypt was reported to be 64-65 kg/capita/year. Egyptians have developed fermentation procedures to conserve milk during hot summer seasons. Cheese and butter consumption represent half of milk consumption [13].

In Morocco, the consumption of dairy products is around 74 liters/capita [14]. Fresh pasteurized milk represents half of the consumption, followed by whey (16%) and cheese (14%). Disparities are observed between cities that consume almost twice milk and dairy products that in

rural area [14]. Milk prices have been liberalized at the farm level and for the consumer since 1993 [14]. The milk paid to the farmer is on average price of US$ 0.34 with variations that may occur depending on the quality of the milk delivered. As for prices charged at the MCC level, the price of milk is delivered with a premium of US$ 0.05 to US$ 0.01 to cover the operating and management costs of the cooperative (water, electricity, personnel, etc.) [14]. This varies according to the region and the size of the cooperative. The raw milk is sold in the informal circuit at an average price of 0.43 US$.

In Tunisia, milk and dairy product consumption have grown steadily since the 1990's. Milk consumption was reported to be 110 kg/capita/year, with rural areas consuming 3 times less than urban areas. Cheese, however, remains a luxury product [15]. The public authorities currently still control the price of milk. A minimum price for fresh farm-produced milk is periodically set by the government. The certified milk collecting centers got a premium per liter collected, whereas the processors received a premium per liter processed. The consumer price is fixed again. In 2019, the farmer price was 0.28 US$ and the price at consumption was 0.48 US$ [15]. The payment does not differentiate in milk quality reflecting the absence of efforts to improve it. Although the traditional distribution network, based on over 210,000 neighborhood grocery shops scattered throughout the country, continues to dominate the Tunisian market, modern distribution channels are growing rapidly. It represents now 20% of the Tunisian retail sector with a goal to increase the level to 50% in the next years. Currently, there are roughly 252 modern food retail outlets: 3 hypermarkets, 150 supermarkets and 100 'Superettes' (self-service food outlets with area less than 500 sq. m). Neighborhood grocery stores represent a place for local purchases on a daily basis. The range of dairy products they offer is much smaller than that of the hypermarkets and supermarkets. In addition to industrial products, neighborhood grocery stores can offer artisanal products which are generally supplied by small processors in the local area. Deliveries are on a daily basis and in small quantities. They take a significant share of food sales, especially in rural areas. This share is estimated at 80%. France and the Netherlands are the most important partners in supplying Tunisia with dairy products. Tunisia mainly exports to Libya (about 85% in weight).

5. Perspectives of North Africa DLVC within the scope of LIVE2AFRICA

AU-IBAR proposed the "LIVE2AFRICA" programme "The Sustainable Development of Livestock for Livelihoods in Africa". The European Union, in partnership with Member States, Regional Economic Communities and other key livestock stakeholders, funded its implementation. The overall objective of the programme was to support transformation of the African livestock sector for enhanced contribution to environmentally sustainable, climate resilient, socio-economic development and equitable growth. North Africa region selected the Dairy Livestock Chain as its priority in the framework of Live2Africa.

Based on the described DLVCs in the region, opportunities for their enhancement exist and pathways to their future sustainable development are identified. A special focus was put on breeding strategies to improve dairy bovine milk productivity while securing the region's needs in good quality breeding stocks with known breeding values to enhance milk productivity and generate descent incomes to the majority of small holders.

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5.1. **Breeding strategies**

North Africa DLVCs present common features with specific characteristics. The six countries have based their DLVCs on dairy bovine that produce the majority of the regional total milk volume. Almost 100 % of milk produced in Egypt is coming from bovine (56 % from cattle and 44 % from buffalo), more than 96% of milk in Morocco and Tunisia are coming from dairy cattle and 44% of milk in Mauritania are coming from cattle (Dromedary 31 %, goats 23 %). Most of North Africa countries chose, since more than 40 years ago, to import exotic dairy breeds to produce milk locally or import milk powder (Algeria and Libya) to meet the demand of their increasing population. All countries chose to increase milk production through the increase of cow numbers, besides the use of exotic breeds at the expenses of native ones. The milk producing unit (the dairy bovine), used to be native, has seen a deep change in its genetic makeup dominated by exotic breeds. Native cattle breeds used to represent 95% of the total cattle population in the region during the seventies. It is now 43% of the cattle population. Pure exotic bovine breeds and their crosses with native breeds represent, today, more than 50 % of the total bovine population. These producing biological units (cows) are in constant needs to be bred by good quality semen. Breeding goals are usually ignored. A breeding goal is a trait or a number of traits, weighted by their economical weights, computed based on their production costs and prices and including farmers' choices. To achieve the identified breeding goals, traits of interest should be measured and animals breeding values predicted. For these reasons, animal identification, performance recording and genetic evaluation are essential ingredients to be implemented in the region to be able to improve dairy cattle productivity; while providing good quality breeding stocks (heifers and semen). Farmers' organization are a prerequisite for such ingredients, besides suitable extension and applied research to improve health, feeding and herd management. Today, most of dairy producers are small holders (90%) with no influential power in the dairy value chain, compared to milk collecting centers, processors and distributors.

The region has approximately 3 million cows of which a known percentage is identified in 3 countries Egypt (18%), Morocco (62%) and Tunisia (29%). Table 4 shows that the only country capable to meet its local needs in heifers replacements and produce an extra number of identified heifers without known breeding values is Morocco. This situation can be enhanced if Morocco expands its recording system to cover all cows that are already identified. For herds with identification and milk recording, Morocco and Tunisia have the potential to produce a surplus of heifers for the existing dairy herds with milk recording. Produced heifers can be ranked as good quality heifers if their breeding values are computed.

Table 4. Egypt, Morocco and Tunisia capacity to produce dairy heifers

Operational model	**Egypt**		**Morocco**		**Tunisia**	
	Identified cattle only	**Identified cattle with dairy records**	**Identified cattle only**	**Identified cattle with dairy records**	**Identified cattle only**	**Identified cattle with dairy records**
Cows	532800	NA	738000	60000	120000	13000
Fertility	0.8		0.8	0.8	0.8	0.8
Born calves	426240		590400	48000	96000	10400
Calf mortality (5%)	21312		29520	2400	4800	520
Live calves	404928		560880	45600	91200	9880
Live female calves	202464		280440	22800	45600	4940
Culled female calves (10%)	20246		28044	2280	4560	494
Produced females	182218		254396	20520	41040	4446
National cow number (1000)	**2960**		**1200**		**412**	

National Dairy herds replacement needs (20%)	592000		240000	12000	82400	4000
SURPLUS/DEFICIT HEIFERS	**-409782**		**+14396**	**+8520**	**-41360**	**+2840**
Produced Replacements/Country needs	**0.31**		**+1.06**		**0.50**	
% identified cows/Total cows		**18**		**62**		**29**
% Recorded cows/Identified cows		**0**		**8**		**11**

AU-IBAR through the Live2Africa program can play a key role in enabling North Africa region to establish coherent national or regional breeding strategies founded on milk recording system, genetic evaluation and farmers' organizations. This is the only potential pathway to produce good quality breeding stocks, optimize replacement operations and improve herds' productivity in a sustainable way.

5.2. Proposed Catalytic Actions to boost the DLVC in North Africa

AU-IBAR has the opportunity to implement identified needed catalytic actions while responding to all North Africa DLVCs previous workshops considerations, which recommended three main priorities: 1)Valuation of Dairy herds to produce good quality breeding stocks, 2) Valuation of Animal Natural Feed resources and 3) Building capacity through training and farmers organization focusing on small and medium holders. This is possible, given that North Africa has now a potential bovine germplasm with superior genes. The recommended catalytic activities working package aims to produce good quality dairy breeding/replacement stocks (heifers male calves and semen), while improving dairy cattle milk productivity. The operational mechanism of the working package includes a reliable genetic gain/ breeding program, supported with feeding and health management systems and farmers organization. A special focus is put on small and medium holders and milk collecting centers. This approach is dictated by the existence of a high number of small holders and the willingness to empower them to become real players among the remaining DLVC stakeholders in the region. Outputs of four main workshops were taken into consideration. The North Africa DLVC Validation workshop that was organized, online, on December, 2020. The Stakeholder Consultation on Annual Implementation Plan of Live2Africa Activities in North Africa that was held in Cairo on January 2020. The Stocktaking Exercise (Stakeholders Workshop, to build consensus among stakeholders on the identified milk value chains' priorities and translate them into DLVCs catalytic activities, that was held in Cairo on August, 2019 and the Livestock Value Chain Prioritization Workshop, that was organized in Nairobi, Kenya on February 2019. Knowing that countries, in the region, are at different stages of development in relation to the dairy bovine value chain, the recommended working package is flexible enough to give freedom to countries to choose their starting activities phase and their breed of choice. It is important to underline that even though Algeria and Libya were not included in the AU-IBAR Breeding Goals consultancy (2020), they can benefit from these catalytic activities. The working package has two (2) main phases of implementation. Phase 1, "the

starting point" has three levels. The Advanced level (level 1) that corresponds to countries that has already a national program to produce heifers. The choice should be to include small and medium holders, whose animals are identified, to be a part of the national recording system. The percentage of cows enrolled in the recording system is very low in the region. In the two countries having a national recording system, cows with recorded milk data represent 6 % and 11 % in Morocco and Tunisia, respectively. The remaining countries in the region lack national milk recording systems. Policy makers should be aware of the importance of establishing national milk recording systems for the country to be able to produce good quality breeding stocks and improve herds management and productivity. A management herd/heifers feeding program should be implemented, while bringing small and medium holders in an economic form of association. The National Research Program, with its extension channels, should play a key role to transfer technology and innovations. The Medium level (level 2) is for countries with no milk recording system but have milk collecting centers or milk processing units. In this case, the milk-collecting center or the milk-transforming unit or both should be chosen as focal points to create a network with small and medium farmers, supplying milk to them. These farmers constitute the target farms where to implement animal identification and milk recording activities to become the nucleus of producing future breeding stocks. This might be the case of all countries in the region to upgrade their milk collecting system to become leaders in setting up animal identification and simplified coherent milk recording systems. There is a big room for improvement at this level. Milk collected through organized channels represents 4%, 20%, 25%, 70% and 80% in Mauritania, Egypt, Algeria, Tunisia and Morocco, respectively. A management herd/heifers feeding program should be implemented while bringing small and medium holders in an economic form of association. The country can expand the project to reach more dairy farmers and increase its capacity in producing good quality breeding stocks while producing more milk. This phase will create a dynamic within the DLVC and strengthen the networking among its different segments. The National Research Program with its extension channels should play a key role to transfer technology and innovations. The starting from "scratch" level (level 3) applies to countries that do not have any milk recording, milk collecting centers and any milk-processing units. In this situation, the starting point should be the establishment of a small milk-collecting center to serve as a focal point for small and medium holders where they sell their milk. These farmers should constitute the target farms where to implement the animal identification and the milk recording activities. They become the nucleus of producing breeding stocks. A management herd/heifers feeding program should be implemented while bringing small and medium holders in an economic form of association. Three strategic components (priorities) should be implemented to empower the DLVC in the region while producing good quality breeding stocks. The strategic activity (1) or the genetic gain component. This component includes setting up a reliable breeding program with the participation of the project target farmers as well as existing available dairy recorded herds in the country to produce good quality replacement heifers, male calves (and in further stage semen). This catalytic activity (the Genetic component) should include identification of the breeding goals, animal identification, performance and pedigree recording, genetic evaluation and production of good quality heifers, male calves (and semen). The strategic activity (2) or the improved dairy herd management component. This component includes setting up a coherent feeding and health extension program applicable to target farms. The objective should be the reduction of feed costs while producing healthy good quality milk

and dairy breeding stocks. Aiming to reduce nonproductive lifetime of future cows will encourage the establishment of a coherent feeding ration to heifers and a continuous monitoring of their standardized weights until pregnancy. The strategic activity (3) or the empowerment of small and medium target farmers component. This component will support forming breeders/breeding associations or economic grouping forms between milk collecting centers and small/medium holders, which will allow target farmers to have a decisive role within the Dairy Bovine Value Chain in the country. Each country in the region should aim to establish a national dairy bovine breeding program based on a complete National Animal Identification and Performance Recording System. This program should enable the country to set up a national Dairy Cattle/Buffalo Breeding Scheme where the recorded herds will be divided in two major classes

a. Large and medium size herds to constitute the national breeding nucleus. Semen from Active proven sires could be imported to benefit from the genetic progress made worldwide and used on the best producing cows.
b. Small recorded herds can benefit from good quality female breeding stocks from the nucleus herds.
c. A third category with no records constitutes the remaining cattle/buffalo populations to be served by breeding stocks of (a) and (b).

Training human resources of the region in sustainable animal genetic resources management for genetic gains is essential in order to sustain the proposed catalytic activities. Exchange of visits among farmers of the region to exchange experience and skills will pave the way to implement North Africa regional activities to boost the DLVC and upgrade its levels for the benefit of all its stakeholders while producing good quality milk and milk products to consumers.

Conclusions

Since the seventies, North Africa region invested heavily in the livestock dairy sector to meet the needs of a growing population, reaching today more than 209 million consumers, half of them are in Egypt. Oil producing countries in the region followed milk powder importation strategy and the remaining ones chose to import exotic dairy cattle, mainly Holsteins, to produce milk locally. The status of the Dairy Livestock Value Chain in the region, today, is based mainly on bovine milk production from dairy cattle and buffalo. Native cattle decreased from 95% to 43% showing the rate of loss of native bovine biodiversity in the region. Exotic dairy breeds are raised in favorable irrigated areas while native cattle are left in extensive production systems. More than 90% of milk producers belong to small holders with a few cows. The milk value chain is still traditional in most countries of the region with organized channels of milk collecting and processing representing 4%, 20% and 25% of the total milk produced in Mauritania, Egypt and Algeria, respectively. However, milk collecting and processed milk through organized channels represent 70% in Tunisia and 80% in Morocco. Opportunities for empowering the DLVC exist, given that the region has a valuable germplasm of purebred cows and buffaloes capable to produce efficiently while producing good quality breeding stocks for replacements and improvements. Average milk consumption is estimated to grow in the coming years and imports of milk, milk powder and breeding stocks will be at a very high cost. Catalytic actions are needed at all levels of the DLVC. Investing in the establishment of reliable breeding strategies focusing on breeding goals, animal identification, recording and genetic evaluation is an opportunity for the region to boost its DLVCs. Empowering milk small holders through

organizations to back such strategies and become real stakeholders is essential. This is possible because all countries in the region are shifting their efforts to produce milk locally based on productivity and milk quality. The pandemic of COVID-19, which forced countries to close frontiers, constitutes a signal to policy makers in the region to empower their countries livestock sector with a special focus on dairy bovine chain values and suitable alternatives to reduce breeding animals and semen imports. Such an option will reduce their dependence on imports of dairy bovine breeding stocks and dairy products to satisfy their increasing population growing demand in livestock products.

6. References

1. Delgado, C.; Rosegrant, M.; Steinfeld, H.; Ehui, S.; Courbois, C. 1999. Livestock to 2020: the next food revolution. IFPRI Food, Agriculture, and the Environment Discussion Paper 28. Washington, D.C. (USA): IFPRI.
2. OECD/Food and Agriculture Organization of the United Nations (2019), "Dairy and dairy products", in OECDFAO Agricultural Outlook 2019-2028, OECD Publishing, Paris/Food and Agriculture Organization of the United Nations, Rome. DOI: https://doi.org/10.1787/7ccc11c6-en
3. FAO, IFAD, UNICEF, WFP and WHO. 2019. The State of Food Security and Nutrition in the World. Safeguarding against economic slowdowns and downturns. Rome, FAO. https://www.fao.org/3/ca5162en/ca5162en.pdf
4. AU-IBAR. 2019. The LIVE2AFRICA Livestock Value Chains Workshop, Nairobi, Kenya-19-21 February 2019.
5. Characterization of milk value chains in North Africa. 2019. A stakeholder stocktaking exercise. AU-IBAR Desk Review.
6. The Stakeholder Consultation on Annual Implementation Plan of Live2Africa Activities in North Africa. 2020. AU-IBAR Consultative Workshop, Cairo Egypt.
7. AU-IBAR, 2020. Assessment of the National Breeding Objectives and Implementation of Supporting Programs/Initiatives for Dairy Livestock Value Chains, DLVCs, in North Africa". LIVE2AFRICA PROJECT. Dairy Livestock Value Chains. DLVC Regional Report.
8. The Global Economy.com. 2019. https://www.theglobaleconomy.com/
9. UNPF, 2021. https://www.unfpa.org/data
10. Caroline Emond, 2019. The World Dairy Situation. International Dairy Federation. https://agriprofocus.com/upload/post/CAROLINE-EMONDmin_(1)1573130127.pdf
11. FAO. 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture, edited by B.D. Scherf & D. Pilling. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome (available at http://www.fao.org/3/a-i4787e/index.html).
12. FAO, 2019. http://www.fao.org/faostat/en/#data
13. AU-IBAR, 2020. Assessment of the National Breeding Objectives and Implementation of Supporting Programs/Initiatives for Dairy Livestock Value Chains, DLVCs, in North Africa". LIVE2AFRICA PROJECT. Dairy Livestock Value Chains Egypt Country Report.
14. AU-IBAR, 2020. Assessment of the National Breeding Objectives and Implementation of Supporting Programs/Initiatives for Dairy Livestock Value Chains, DLVCs, in North Africa". LIVE2AFRICA PROJECT. Dairy Livestock Value Chains Morocco Country Report.

15. AU-IBAR, 2020. Assessment of the National Breeding Objectives and Implementation of Supporting Programs/Initiatives for Dairy Livestock Value Chains, DLVCs, in North Africa". LIVE2AFRICA PROJECT. Dairy Livestock Value Chains Tunisia Country Report.
16. Borghese, A. and Mazzi, M. 2005. Buffalo Population and Strategies in the World. In: Buffalo Production and Research, FAO, Rome. http://www.fao.org/docrep/010/ah847e/ah847e00.htm
17. Annabelle Daburon , Mohamed Radwan , Véronique Alary , Ahmed Ali , Sherif Abdelghany and Karim Fouad. Evolution of a milkshed and role of alternative milk collection centres in Egypt. 2016. https://doi.org/10.1051/cagri/2016049
18. Salah Galal. 2007. Egyptian J. Anim. Prod. Issued by The Egyptian Society of Animal
19. Alary V., Radwan M., Abdelghany S., Corniaux C., Galal S., 2015. L'approvisionnement en lait du Caire. Atelier DEFIT/SELMET, CIRAD, mars 2015.
20. FAO. 2018. Africa Sustainable Livestock 2050. Livestock Production Systems spotlight. Egypt Cattle and Buffaloes and Poultry sectors.
21. AU-IBAR, 2020. Assessment of the National Breeding Objectives and Implementation of Supporting Programs/Initiatives for Dairy Livestock Value Chains, DLVCs, in North Africa". LIVE2AFRICA PROJECT. Dairy Livestock Value Chains Mauritania Country Report
22. AU-IBAR, 2020. Assessment of the National Breeding Objectives and Implementation of Supporting Programs/Initiatives for Dairy Livestock Value Chains, DLVCs, in North Africa". LIVE2AFRICA PROJECT. Dairy Livestock Value Chains Regional Report
23. MOA-OEP,2020. Indicateurs du secteur de l'élevage en Tunisie. www.oep.nat.tn
24. Djemali, M. and P. J. Berger. 1992. Yield and Reproduction Characteristics of Friesian Cattle Under North African Conditions11992 J Dairy Sci 75:3568-3575
25. GIVLAIT, 2020. Présentation de la filière lait. http://www.givlait.com.tn