FinExCoop' Genetic initiative for cows

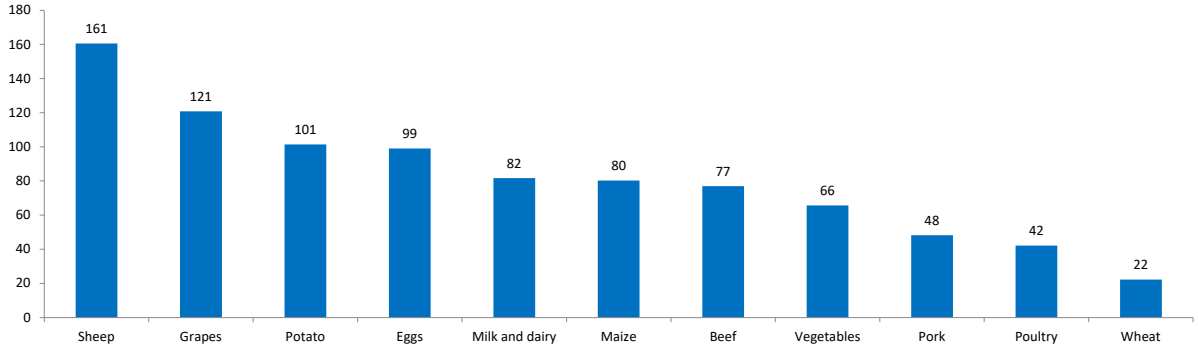
I Background: beef-and-dairy, a poorly performing value-chain with negative socio-economic and environmental consequences

1) The demand side: geared towards more consumption

The AFD/EU FinExCoop project, launched in October 2019, is currently involved in support to four value-chains, both at national/horizontal level, and at pilot/local level. Beef-and-dairy is one of these value-chains.

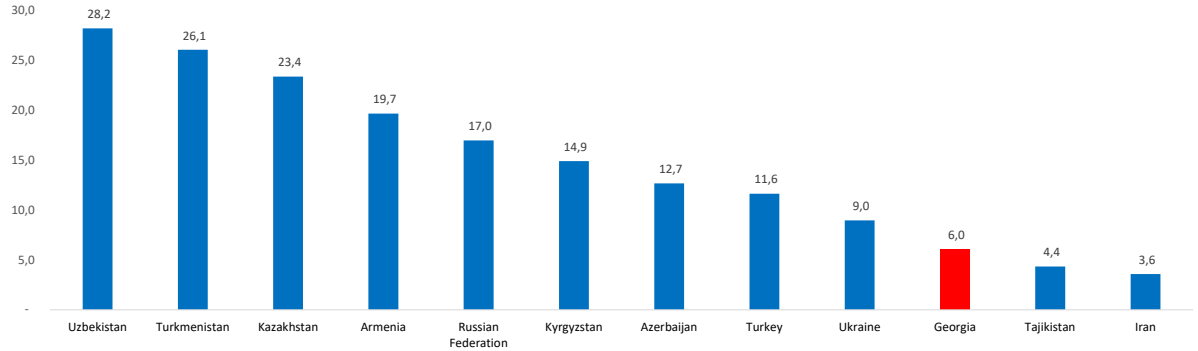
Despite availability of vast mountain pastures and very good agronomic conditions for the production of intensive fodder (especially maize), which allowed the country to be a large net exporter in FSU, Georgia is nowadays a large net importer of milk/dairy products and of beef meat.

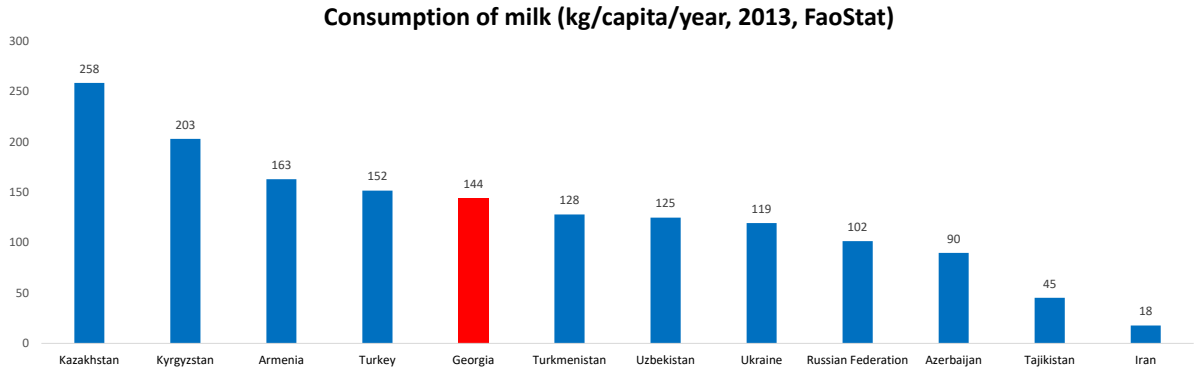
Self sufficiency ratio (%, 2018, GeoStat)



The poor results for external trade are rather problematic in terms of Food sovereignty as Georgian levels of consumption per capita for the consumption of beef remain very low by regional standards.

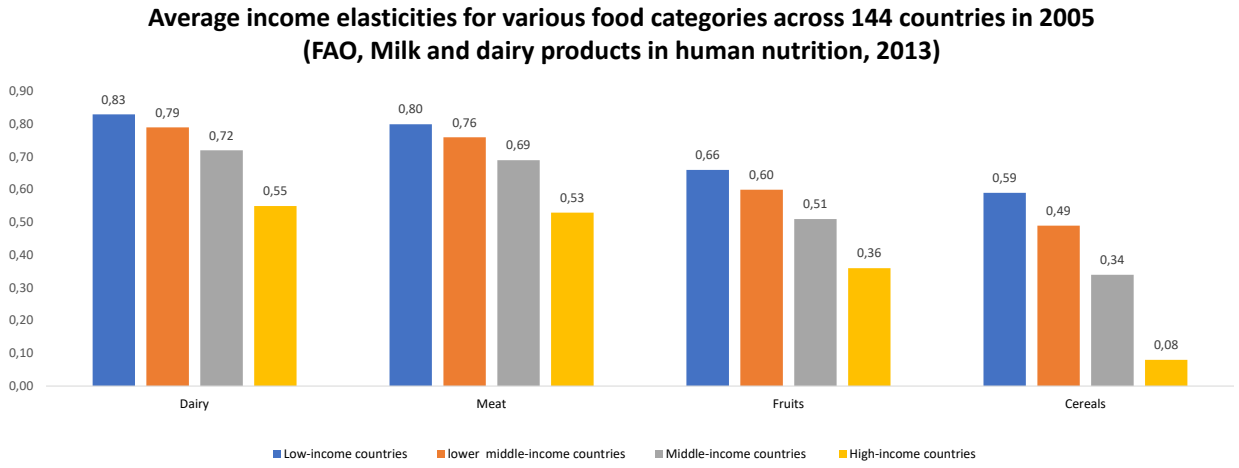
Consumption of beef (kg/capita/year, 2013, FaoStat)





Even though cheese plays an important role in Georgian cuisine and diet, in addition to other traditional dairy products such as Matsoni, the Georgian consumption of milk products per capita also remains modest and is below WHO recommendations[1].

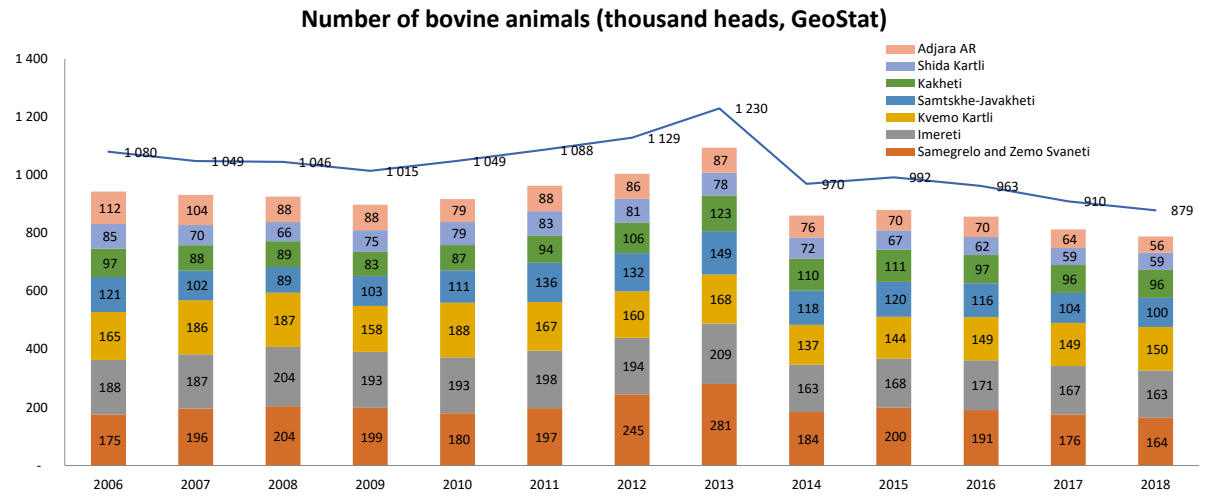
In the future, it is expected that improved income of the population will translate into substantially bigger demand for beef meat and dairy products, as Georgia is a middle-income country for which income elasticity of demand for these types of products remains high. Will the local production be able to cope with this increased demand?



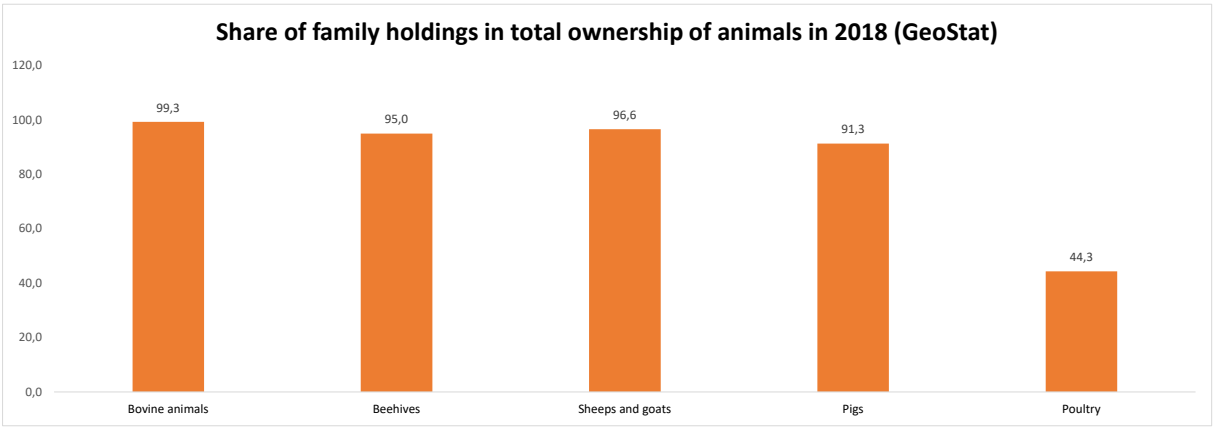
2) Evolution of the supply base: stagnation

In 2018, according to GeoStat, there were 879 thousand bovine animals in Georgia, substantially less than at the beginning of the previous decade. Animals were located all over the country.

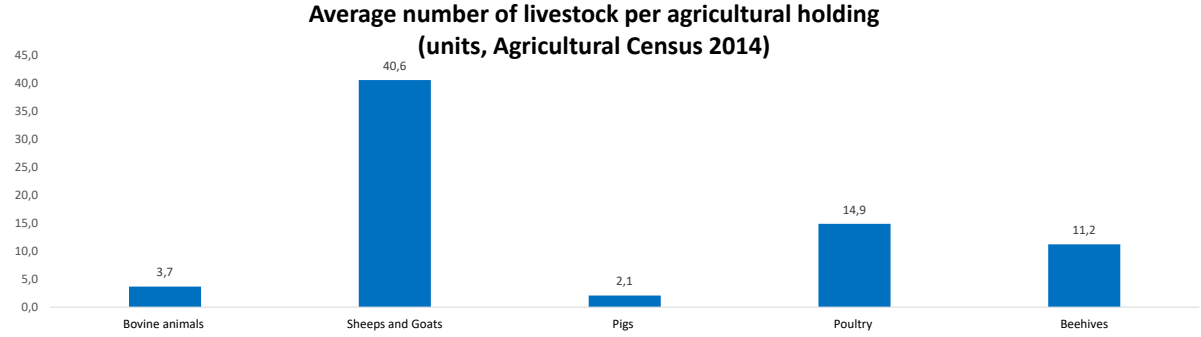
[1] http://www.euro.who.int/__data/assets/pdf_file/0017/150083/E79832.pdf



Nearly all (99.3%) bovine animals are owned by family holdings as in other FSU countries that have opted for small-scale family agriculture including Armenia and Azerbaijan.

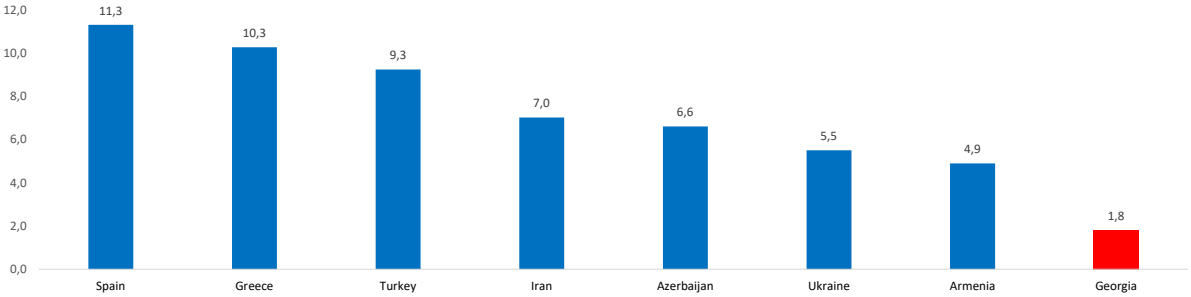


On average, there are 3.7 animals per farm. Very often, cows graze together in communal pastures where they have intercourse with bulls, without any control. Heifers that have not finalized their body growth become pregnant too young, putting in jeopardy their own productive capacity and favouring a genetic degradation of their calves which suffer from dwarfism. There is also widespread dissemination of contagious diseases like brucellosis through natural reproduction.



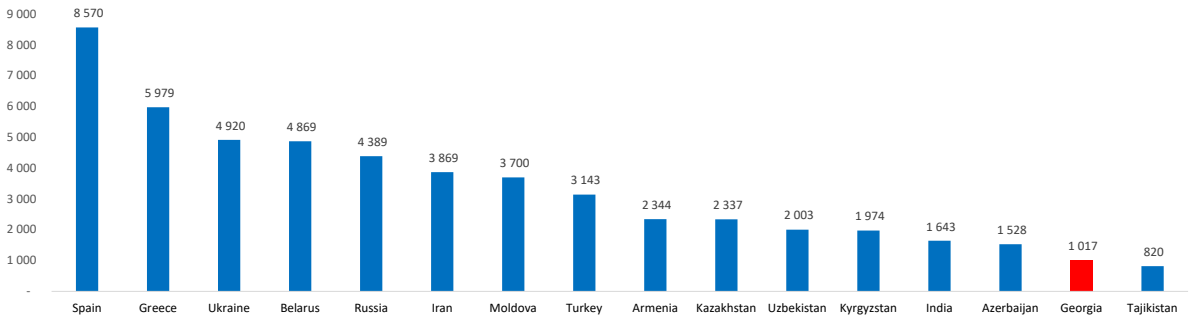
The genetic degradation of animals is associated with poor feeding practices. Fodder is usually badly harvested and stored, and therefore it has a low content of protein and low digestibility of fibre, whether it is produced under the form of hay or of silage. It is also often insufficient in volume. Yields for fodder crops are very low including for cereals like maize for which Georgia has much stronger natural comparative advantages than its neighbours. Rations are not balanced and there is limited use of minerals and vitamins except in the largest farms. A recent study conducted in Kvemo Kartli and Samtskhe-Javakheti by Milliman/IFAD[2] encompassing a milking cow population of 4,604 animals, showed that almost 40% of farmers never offer their cows more than hay which is usually of poor quality as most farmers lack the equipment to harvest it on time. As these two regions have, according to GeoStat, higher yields than elsewhere (respectively 1,736 l/year and 1,600 l/year against a Georgian average of 1,486 l/year in 2018), it is probable that this ratio is a national minimum.

Compared yields of maize (2017, t/ha, Faostat)



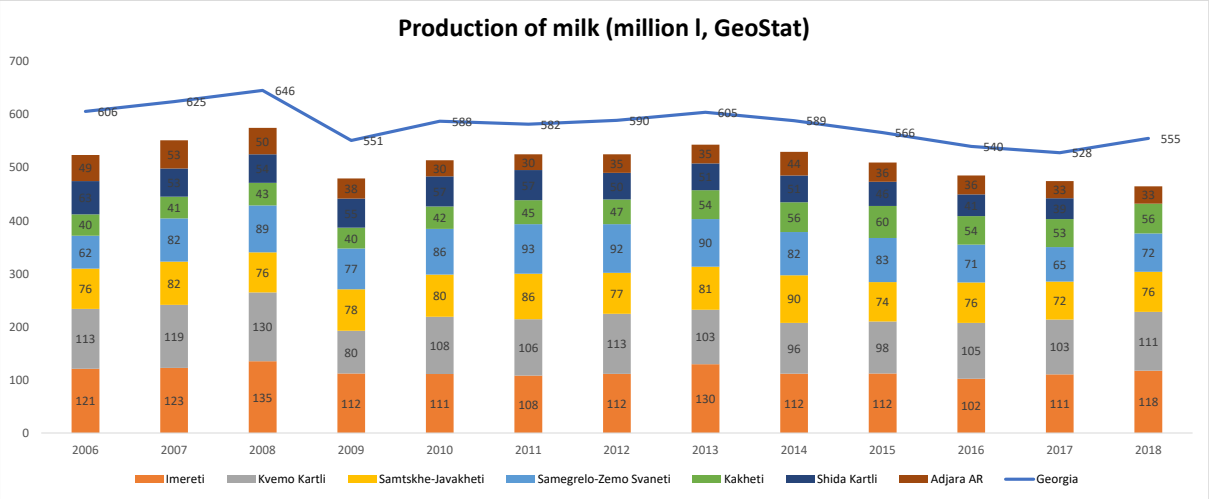
Against this background, Georgian yields for milk and meat remain miserable by FAO statistics which show lower yields than GeoStat.

Yields of milk, whole (l/cow/year, 2017, FaoStat)

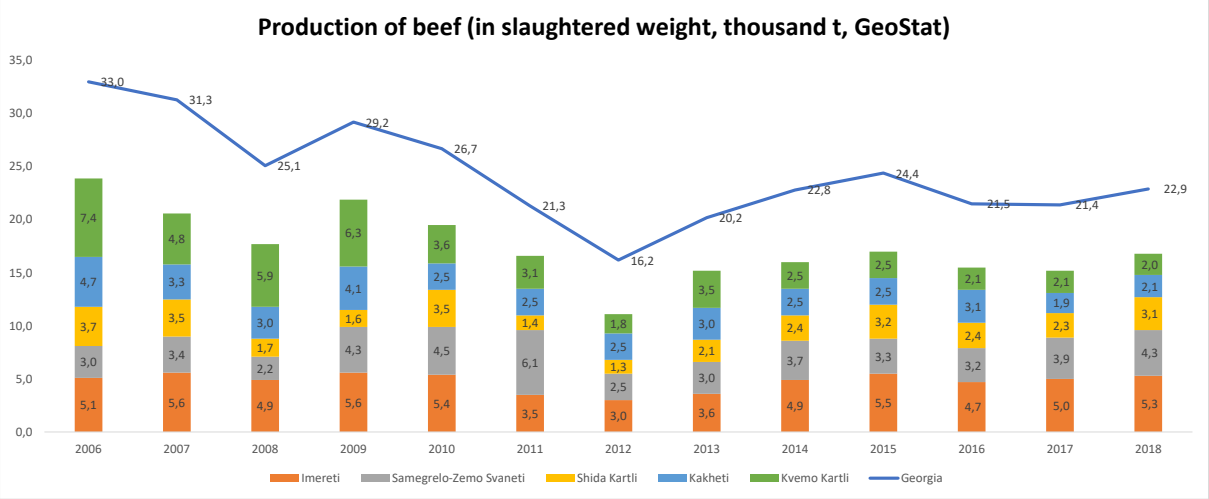


The combination of poor yields with fewer animals has translated into decline in milk output.

[2] *Mortality of dairy cows in Georgia. From guesswork to data through farmer surveys, Managing Risks for Rural Development: Promoting Microinsurance Innovations*, March 2020.



The decline in beef production has been even more acute as many male calves are exported to Azerbaijan for bull fattening.



The low levels of productivity of Georgian cows have not only food sovereignty and socio-economic impacts, they have also a very negative environmental impact. According to the *Greenhouse Gases (GHG) inventory Report of Georgia, 1990-2015* (2019), enteric fermentation and manure management were responsible for 71% of GHG emissions in agriculture in Georgia in 2015, and with 11% of total emissions in CO2-equivalent were only second to road transportation in terms of emissions of GHG. Needless to say that the ratio l of milk and kg of meat per unit of emitted GHG could massively increase through adequate improvement strategies. As can be seen on the following table, there is already a large difference between so-called early-maturing cows (cows improved during Soviet times with genetics such as black-and-white) and traditional Georgian Mountains and Mingrelian Red

cows[3]. Early maturing cows emit 40% less GHG per l of milk than Georgian Mountain cows and 55% less GHG per kg of live weight.

It must be noted that environmentally-sustainable management of livestock is a key component of the new Farm to Fork Strategy of the EU, as part of its Green Deal Initiative. It will apply both to the new cycle of the EU Common Agricultural Policy but also to its international development support[4].

	Greenhouse Gases (GHG) inventory Report of Georgia, 1990-2015 (2019)							
	Number of cows 2015 (units)	Number of cows 2015 (% of total)	Live weight 18 months males kg	Live weight 18 months females kg	Average lactaction (kg/year)	Emissions of CH4/head (kg/year)	Emissions of CH4/head (kg/year)/kg of live weight males 18 months	Emissions of CH4/head (kg/year)/kg of milk
Georgian mountains cow	546	40	160	130	1358	47	0,29	0,035
Mingrelian red	546	40	210	190	1460	47	0,22	0,032
Early maturing	273	20	458	345	2610	58	0,13	0,022
	1365	100						

II What can be done to improve the situation?

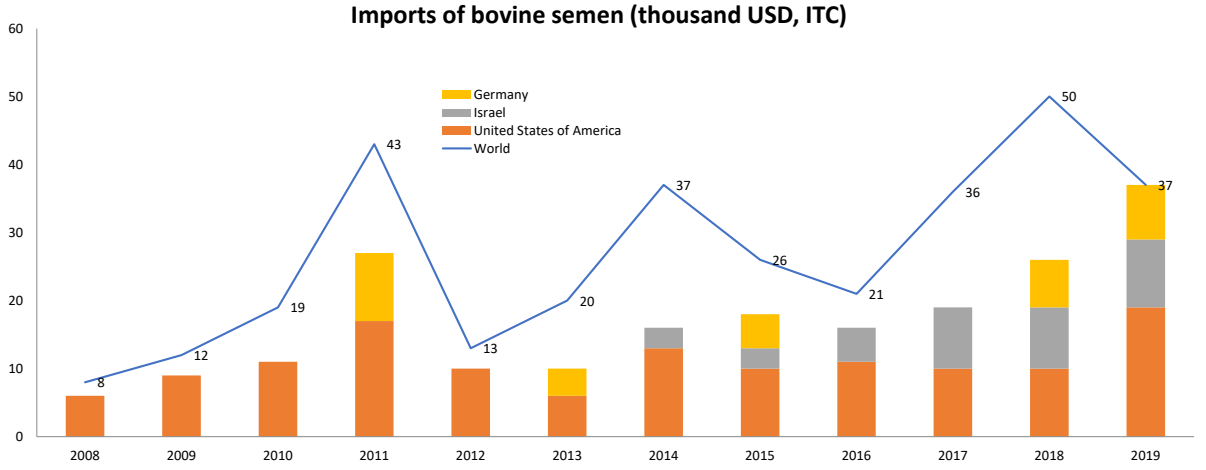
1) Mobilization of support

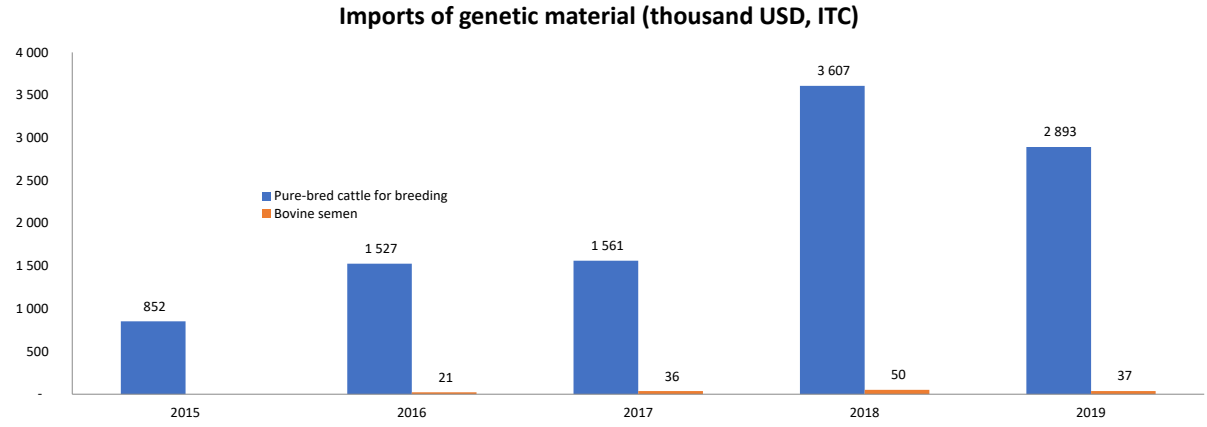
In the past, apart from small-scale projects such as the one of the French NGO FERT/Georgian GBDC in Samtskhe-Javakheti, or the Technical Assistance to Support the Establishment of a National Animal Identification, Registration and Traceability Systems (NAITS) in Georgia financed by the Swiss and Austrian development agencies, not much had

[3] There are substantial differences between FaoStat, GeoStat and statistics provided by this GHG study. It may be that yields and output are somewhat under-reported because households considered as poor benefit from targeted State support and try to hide part of their income from cattle. Live weights given by the GHG inventory also seem extremely low. Anyway, even though real figures are probably higher than official ones, the key elements of the diagnostic remain valid.

[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_en.

been done by the development community to technically improve the situation in beef-and-dairy. Many development projects were "humanitarian" in essence, usually implemented by NGOs, and did not lead to any substantial technological improvement. For instance there was virtually no work done on the improvement of local breeds with imported genetics for artificial insemination: imports of this kind of genetic material remain under 10,000 doses per year, covering less than 1% of the needs of local cows. As shown by the origin of imports, mainly from Israel and the USA, specialized in "Ferrari" genetics not suited to the capacity of smallholders, these imports were focused on a very limited number of large modern intensive dairy farms. They were associated with some imports of pedigree cattle by the same farms, usually disconnected from their socio-economic environment and therefore unable to play a pull force to help change breeding practices of small and medium-size farmers.





Recently, GoG and its development partners have decided to address the issue of under-development of the beef-and-dairy sector more decisively.

Two large-scale projects, which have just been launched, are in particular expected to play a leading role in the rebuilding of the sector and its socially-inclusive modernization:

- The IFAD/MEPA Dairy Modernization and Market Access Project (DiMMA), with a project cost of USD 53.4 million (USD 18.2 million contribution from IFAD), will support smallholder producers at risk of losing their markets (because of the increased focus of large dairy processors on supplies from a limited number of modern farms, often less than 10 all over the country, and on their dependency on imported powder milk). It will provide them the know-how and technologies to upgrade their milk production systems, adopt food safety standards and comply with the food hygiene regulations. Initially planned to be implemented in three regions, Samegrelo and Zemo Svaneti, Imereti, and Samtskhe-Javakheti, it will eventually be active all over Georgia. It will contribute to import substitution by increasing the local supply of high-grade milk to dairy-processing enterprises. It will also improve the productivity of dairy animals through better nutrition, veterinary care[5] and breed improvement activities

- The USDA Safety and Quality Investment in Livestock (SQIL) project is funded by USDA Food for Progress 2018 program and implemented by the Land O'Lakes Venture37 (former Land O'Lakes International Development) partnering with the Michigan State University and the Georgian Farmers' Association. It is expected to improve food safety and quality along Georgia's dairy and beef value chains. From farm-to-fork, this project aims to reduce losses, and boost competitiveness, productivity and trade of milk and meat products. The project has already produced reference strategic documents on the beef-and-dairy value chain and developed a system of calculation of rations for nutrition adapted to the needs of local breeders[6]. Another important component of the project is the promotion of better housing for cattle with due care given to efficient ventilation of cowsheds. It is also beginning to provide co-investment grants.

2) FinExCoop's strategy in beef-and-dairy

[5] A special component of DiMMA deals with the promotion of private para-vets as according to IFAD "the public veterinary services are understaffed (36 persons at national level, 120 in the field) and therefore face difficulties to fulfil their responsibilities related to veterinary public health (control of TADs and zoonotic diseases, including brucellosis) and food safety (inspection of food of animal origin). For vaccination campaigns and disease surveillance, they therefore sub-contract private veterinarians and paravets (650 in total), which is a classic arrangement. The veterinary legislation has been assessed by the OIE. However, despite recent amendments, the legislation appears outdated (the core text originates from 1965) and would require a complete revamping to comply with the actual OIE international standards19. This would be a prerequisite to be allowed to trade animal products with other countries, with EU in particular. Public Veterinary Services receive significant support from the EU under the ENPARD programme to upscale their capacities, and in particular improve veterinary public health aspects".

[6] Cf. Safety and Quality Investment in Livestock (SQIL)/ISET, *Georgian Dairy Market System Analysis and Mapping*, May 2019; SQIL/PMO Business Consulting, Georgian Beef Market System Analysis and Mapping, May 2019; SQIL/ISET Georgian Dairy Market System Analysis and Mapping, May 2019; SQIL/PMC, *Needs Assessment Study on Existing Market Price Information and Distribution Channels of Dairy and Beef Products, and Livestock Feed Varieties*, March 2020; SQIL/GFA, *Food Security Systems in Pandemic: Beef and Dairy Value Chains*, May 2020.

FinExCoop's financial resources dedicated to the beef-and-dairy value-chain are modest compared with those of these two projects with which it has developed close cooperation. However, FinExCoop benefits from four comparative advantages:

- Its management agility with a process of decision-making that has proven extremely reactive, in particular during Covid 19
- Its unparalleled international network of skilled professionals with both large practical experience all along the beef-and-dairy value-chain and proven capacity to work in development projects
- Its unparalleled international network of technological partner companies already mobilized together in other countries of the region such as Tajikistan, and which are willing to take a proactive stance to develop their activities in Georgia
- Its integrated pilot development platforms that are including all the key stakeholders in the value-chains to allow a farm-to-fork development process and that are expected to play a clustering role for socially-inclusive modernization and competitiveness.

FinEXCoop sees three main areas where it can contribute to provide substantial improvement taking into account that other components will be largely handled by IFAD/EPA DiMMA (veterinary services) and by Land O'Lakes SQIL (housing):

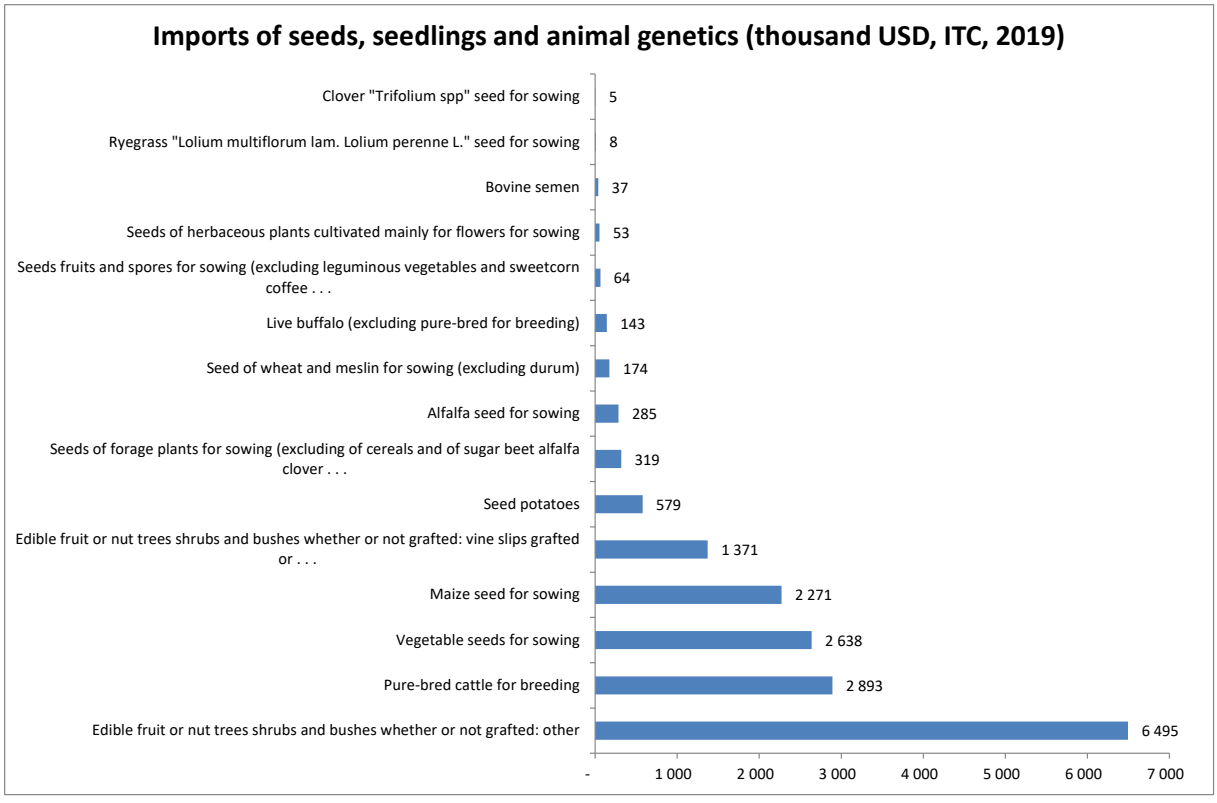
- Fodder and feed
- Genetics
- Post-farm gate activities.

For fodder and feed, FinExCoop has already successfully launched, just after the beginning of its operations, experimental fields with advanced farmers in its pilots and with four global leaders and technological partners who have provided their seeds for free for these initial tests:

- Jouffray-Drillaud (www.jouffray-drillaud.com), winter forage mixtures
- Florimond-Desprez (www.florimond-desprez.com), winter wheat, winter barley, durum wheat, winter pea, winter triticale, spring pea, fodder beets
- Limagrain (www.limagrain.com), maize for grain and for silage
- RAGT (www.ragt.fr), rapeseeds.

FinExCoop has also tested together with FAO the use of new zero till equipment from Brazil for the production of fodder crops and other crops.

FinExCoop plans to keep on systematically developing experimental and demonstration fields for fodder both for the production of energy and proteins (maize, sorghum, triticale, barley, wheat, fodder beets, peas, vetch, alfalfa, sunflower, clover, sainfoin, lupine, faba beans, rapeseeds, flax). Improvement of mountain pastures through experimental plots will also be done. It must be highlighted that imports for these types of seeds are currently very limited.



To produce and harvest this fodder, FinExCoop is also working on the setting-up and development of cooperatives of use of agricultural machinery in its pilot development platforms. These cooperatives will take advantage of the long and successful experience of the French CUMAs in this field[7]. FinExCoop expects these Georgian CUMAs to be co-financed by leading development projects such as FAO ENPARD and by preferential agro-loans supported by ARDA and provided by commercial banks. As for seeds, it expects a strong commitment of global suppliers of machinery and equipment which will use the pilot development platforms to promote their products in Georgia. Global leader Kuhn (https://www.kuhn.fr) has already accepted to provide its equipment with a 25% demonstration discount for the first piece bought.

In parallel, together with advanced international nutrition companies such as MG2Mix which is producing in Georgia[8] or the Turkish company Golden grains which has launched a production of feed based on by-products of the beer industry, FinExCoop intends to promote the development of feed complementation bags for smallholders, especially for proteins, minerals and vitamins.

Regarding post-farm gate activities, FinExCoop is focused on the development of dairy cooperatives which could:

- Potentially contract with large-scale off-takers and act as milk consolidators with their cooling tanks, provided they can enforce strict procurement discipline among their members in terms of milk quality and hygiene for which FinExCoop will provide training and coaching
- Potentially develop their own capacity for small and medium-scale dairy processing focused on diversification of their product mix towards higher-value products (hard cheese, brand cheese with geographic indications) which can extract high retail prices if well supported by adequate marketing.

These post-farm gates activities are already well on track thanks to the trainings-by-doing provided by the FinExCoop cheese expert Patrick Anglade in the pilots of Kumisi (production of feta and yoghurt), Shiraki + (production of mozzarella) and Mokhe (production of tome de Mokhe as shown on the photo). They will build on the positive and recent experience of FinExCoop's management in Central Asia and elsewhere and be systematically connected with other development projects, including the future EU ENPARD 4 programme in food safety and the training of Georgian students in agro and dairy processing by the Franco-Georgian University (partnership between the Georgian Technical University and the University of Rennes II).

[7] http://www.cuma.fr/
[8] https://www.mg2mix.fr

In this paper, we only focus on the FinExCoop's strategy for genetics. FinExCoop's strategy for fodder and feed and for post-farm gate activities will be dealt with in two other concept notes.

III FinExCoop's strategy in the field of cow genetics

There are four main options to improve the genetics of cows in Georgia:

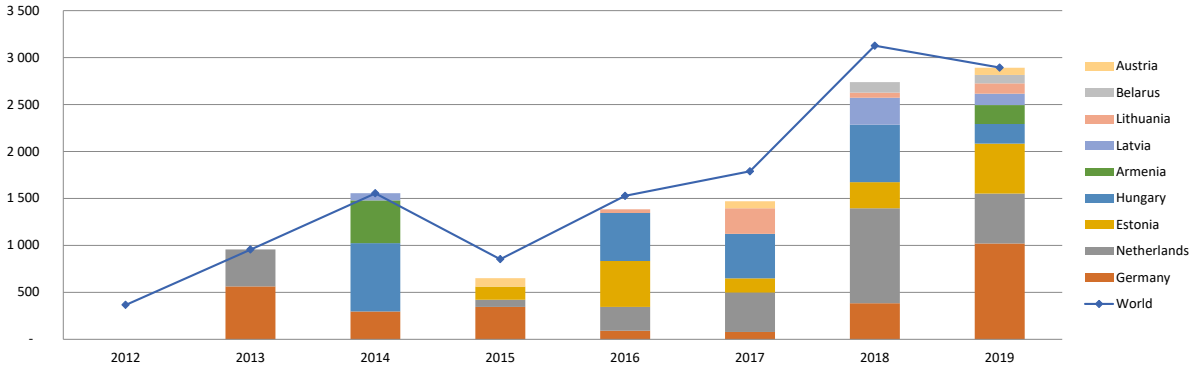
- Import of high quality pedigree animals (pregnant heifers) from abroad
- Transfer of embryos
- Use of artificial insemination for cross-breeding
- Improvement of local breeds through local selection.

1) Import of high quality pedigree animals

Today, as shown by import statistics, this is the only concrete form of genetic improvement in Georgia. However, FinExCoop is convinced that imports of live animals cannot be a long-term solution to rebuild the genetic potential of the country. Its analysis is based on the following factors:

- The cost of imported heifers in Georgia, around USD 2,500-3,000 each, is much higher than in the countries they are imported from, because of transport and transaction costs, and obviously much higher than the cost of best local cows (prices for local cows in the Milliman/IFAD study range from USD 520 to USD 865). Germany and the Netherlands remain the main origin of imports, but the Baltics also play an increasing role. Most imported cows are Holstein and therefore used mainly for milk

Georgian imports of product: 010221 Pure-bred cattle for breeding (ITC, thousand USD)

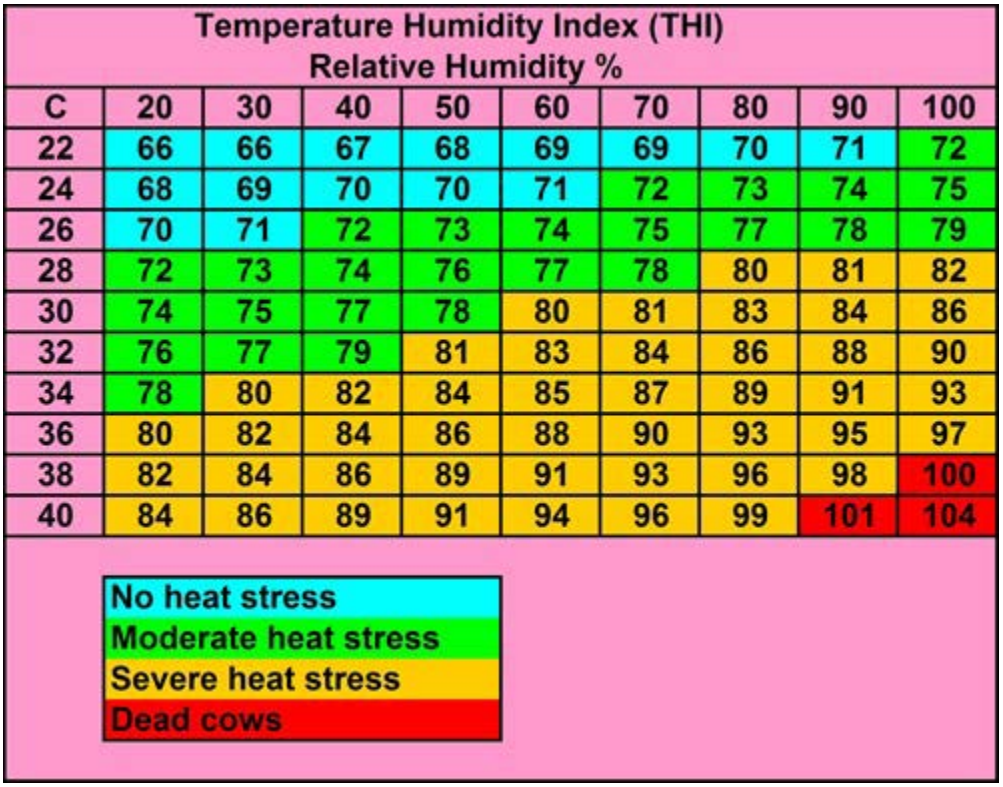


- Because they have no local immunity, and because the breeding capacities of local farmers, even the best ones, remain insufficient to manage fragile "Ferraris", the mortality of imported heifers is very high, often more than 20% some few months after delivery in Georgia. Imported cows have been reported dying from diseases for which they had not been vaccinated in their country of origin, because they just did not exist. Imported cows without enough immunity will in particular suffer from piroplasmosis transmitted by ticks and which is a major cause of deaths of animals in Georgia[9]. Breeding conditions play their negative role too: many cows, usually Holstein, are also reported to have died from acidosis as the silage used to feed them was of poor quality and as farmers provided them with too much concentrate (compound feed) and too little digestible fibre. On the contrary, the Milliman/IFAD study shows that average mortality rates of local cows owned by medium-size farmers in Georgia are only 1.6% per annum: not very productive cows but at least hardy, with an inverse correlation between resilience and productivity

- In Georgian breeding conditions, and except if farms have installed specific costly systems such as showers for watering cows, imported heifers are much less

[9] https://en.redfeatherfarm.org/532-signs-and-treatment-of-cattle-piroplasmosis.html

productive than in Europe, partly because of the negative impact of excessive heat on modern and climate-sensitive imported cows. The more productive a cow, the more it will suffer from heat stress. Imported Holstein are particularly exposed. The combination of high temperature and high relative humidity for these animals is just lethal, especially in Western Georgia where both factors of stress are present. With Climate change, it is expected that heat waves will become recurrent. They may lead in certain cases to deaths of larger cows but also to very poor reproduction capacity as heat has a direct impact in this field[10].



- Because of the combined effect of insufficient knowledge to manage highly productive breeds, poor feeding practices and heat stress, the reproductive performance of imported cows is poor, usually less than 30% at first artificial insemination. Often farmers who have bought expensive pedigree cows use bulls as they are not able to get positive results from artificial insemination. It is of course contrary to best international practices. Intervals between two calves are excessive and translate into lower productivity and higher management costs
- In the absence of State subsidies, and despite the fact that prices of milk in Georgia are higher than in the EU, acquisition of these modern cows is not really profitable, and can only be considered as a short term “bridging” solution” to get larger volumes of milk as soon as possible
- Finally, there is an increasing level of concern worldwide regarding the sufferings of animals sent to distant destinations by truck and which are then after faced with a breeding environment for which they are physiologically poorly adapted. In Germany,

[10] Cf. CEVA, ReprodAction Scientific meetings, *Effect of heat stress on cattle reproduction*, 2015.

the first exporting country of pedigree cows today, mobilization of civil society regarding this issue is becoming very strong (cf. the role of the Animal Welfare Foundation, www.animal-welfare-foundation.org/) and exports to certain distant destinations have already been banned. The new EU regulations are expected to restrict even more the transport of live animals[11].

For all these reasons, FinExCoop does not plan to be involved in genetic improvement through promotion of imports of live cattle. It sees its role only as that of a fair and neutral adviser to potential importers to help them make choices based on better knowledge. It recommends in particular:

- To diversify imports of live cattle towards less productive but more robust breeds which are usually dual-purpose breeds for milk and meat. At this stage, there are very few farms in Georgia that can manage animals whose milking potential is around 12,000 l/year, which is the case for pedigree Holstein. Note that in Europe, Holstein are usually kept for only 3-4 lactations on average and then sent to slaughterhouses as their performances decrease and their health problems increase over time. In the US, their average number of lactations is even lower, at 2.75 on average, and keeps on decreasing. FinExCoop believes that for most farmers who do not possess the technical knowledge to manage these extremely sensitive animals and provide them the perfect environment they need, it is better to invest in less productive cows (per lactation) but which are more robust, easier to reproduce and better for cheese making (for instance yields of kg of cheese per l of milk are 20% higher with Normande than with Holstein because of higher protein and casein including Kappa casein content) and for meat. In general these cows can have a large number of lactations and eventually will produce as much milk as Ferrari Holstein during their lives, and two to three times more calves, which is of critical importance in a country that wants to rebuild its genetic potential[12]. These animals are also able to walk on long distance which is also needed in Georgia as most cattle in the country are kept in mountainous or hilly pastures. In bold letters in the following table, we have underlined the performance of the breeds FinExCoop intends to promote for the production of milk. Montbéliarde, Abondance and Tarentaise are hardy breeds from mountainous regions which are also very resistant to hot temperatures as well. They have been successfully introduced in countries with tough breeding conditions such as the Maghreb, Egypt, Iran or Sub-Saharan Africa, but also Mongolia or Tajikistan.

[11] From Farm to Fork, *op. cit.*, "Better animal welfare improves animal health and food quality, reduces the need for medication and can help preserve biodiversity. It is also clear that citizens want this. The Commission will revise the animal welfare legislation, including on animal transport and the slaughter of animals, to align it with the latest scientific evidence, broaden its scope, make it easier to enforce and ultimately ensure a higher level of animal welfare".

[12] For instance, we could recently visit a farm in France where a Montbeliarde cow had produced more than 100,000 l of milk in her life. The record was that of cow Meri, born in 1996, who gave a total of 178,000 l of milk during 14 lactations.

Normande and Jersey are also hardy cows well suited to warm and humid Western Georgia. French Brown Swiss which have been "Holsteinized" are very sensitive and should not been promoted, but Brown Swiss cows from mountainous regions of Austria or Switzerland have kept their initial resilience and are potentially a good option. Simmental cows are also hardy but as they are nearly meat breeds, there are serious risks of difficult calving.

French Livestock Institute (IDELE) Milk controlled performance 2018				
	Average corrected milk output l/year	Fat content %	Protein content %	Average live weight adult cow kg
Prim'Holstein	11 206	39,7	32,1	650
Brown Swiss	8 920	42,1	34,4	700
Montbéliarde	8 570	39,0	33,2	725
Normande	8 023	42,4	34,7	750
Simmental	7 582	40,2	33,9	750
Abondance	6 450	36,6	33,2	675
Jersian	5 994	55,9	38,7	430
Tarentaise	5 141	37,1	32,6	550
Vosgienne	4 746	37,5	31,5	625

The same considerations apply for meat cows. The import of Charolais cows 15 years ago gave unsuccessful results as this highly productive breed requires highly sophisticated breeders, especially for calving. It is also true to a certain extent for Limousine cows. Better to invest in hardier breeds such as Salers, Aubrac, Hereford and Angus[13].

- For expensive imported dairy cows, reproduction through artificial insemination is a must. As there is a big price difference between male and female calves, it also makes sense to use female sexed semen with these cows, in order to enlarge the pool of animals used for reproduction as much as possible.

2) Transfer of embryos

To obtain quick results in terms of genetic improvement, the only alternative to import of live animals is transplantation of embryos. In this technology, which is now widely used for dairy cows in advanced countries but also in developing countries, embryos are obtained from donors cows (through an hormonal treatment for poly-ovulation and artificial insemination, or in vitro, or from ovules obtained from slaughter houses), usually frozen (but they can also be immediately transplanted on-site), transported in small containers of liquid

[13] Except for some few exceptions of very well managed farm such as the one recently launched by French investor Jacques Fleury and local partners in Dmanisi, which is soon receiving 450 hardy Salers and Aubrac meat cattle from France, we believe that the development of pure meat cattle is not the best economic option. In Georgia the price of milk is substantially higher than in the EU when that of beef meat is substantially lower. Dual purpose cows are a best option first because they are usually hardier and more resilient than pure milk cows

nitrogen and then re-implanted in receiving cows at destination, also using an hormonal treatment. Calves born from embryo transfer combine the quality of their genetic mother-cow and father-cow (pure-bred pedigree animals) with the immunity of their bearing mother-cow, as immunity is mainly transmitted through her colostrum just after calving. It is While it was a costly technology some years ago, transplantation of embryos is now becoming a rather cheap and mainstream technology, much cheaper than imports of live cattle. FinExCoop can potentially source quality embryos from France for no more than 100 EUR per unit. Its experts have recently successfully tested transfer of embryos in Tajikistan with 20-25% positive results, less than half the results obtained in France, but this technology requires time to be fully managed. In the case of Indonesia for instance, where there was a pilot programme of transfer of 1,000 Belgian Blue embryos with professor Hanzen, one of the best experts worldwide, results were initially only 27%. Then they progressively improved. New equipment such as the deep insemination system developed by the Cecna/Elexinn Company can increase results.

Embryos could be particularly interesting for the promotion in Georgia of breeds for which the number of animals is limited in their countries of origin and for which large-scale imports of live heifers are not an option as it is the case for instance with Abondance or Tarentaise cows.

For mountainous areas where it is difficult to track the heat of animals and where the natural tendency of breeders will be to keep using natural reproduction, at least when animals are in summer pastures, embryos could be used to produce on large scale improving bulls for natural cross-breeding with local cows.

FinExCoop plans to test this technology in Georgia with good breeders and the best specialists of insemination, in particular in its pilot project in Kumisi whose leaders have a good practical knowledge of genetic technologies and have specifically requested FinExCoop's support to experiment transfer of embryo. It will work in close connection with Georgian research institutes as transfer of embryos has never been successfully implemented in the country.

Eventually, when Georgia will have rebuilt its technical capacity, it will be able to produce its embryos locally and transplant them fresh to local cows in order to get higher rates of success than with frozen genetic material. Transfer of embryos could also be used to reproduce best cows from local breeds Georgia would like to protect and genetically improve.

3) Artificial insemination

In advanced agricultural countries, genetic modernisation has been largely associated with the use of artificial insemination which developed after the 1950s both as a way to limit the transmission of diseases through bulls (prevention of brucellosis which remains endemic in

Georgia[14]) and as a way to improve genetics through the use of selected pedigree bulls whose qualities are tested both on their ascendants and descendants. Today, in advanced countries, natural reproduction is very seldom used for dairy cows and is limited to meat cows are they are kept most of the time in pastures and more difficult to track. But artificial insemination is also well adapted to the needs of developing countries as shown on the following table where we have summarized the pluses and minuses of different approaches for improving genetic resources.

Technologies	Live animals	Transfer of embryos	Cross-breeding with artificial insemination
Minuses	Very high costs of transport; High mortality of animals during and after transport; Contrary to best practices of protection of animal welfare; Sanitary risks of transport of diseases leading to frequent travel bans No immunity from mother cow regarding local diseases Most receiving farms are unable to generate the same productivity as in countries of origin	Rates of pregnancy are usually below 50%; There is a need to wait for 3 years before cows from embryos become productive (9 months of pregnancy, 18 months of breeding before being used for reproduction, and 9 months of pregnancy for follow-up generation); Most receiving farms are unable to generate the same productivity as in countries of origin;	Genetic improvement takes time. Four generations are needed to get pure bred animals through cross-breeding

In the field of artificial insemination, FinExCoop plans to test three key innovations, sexed semen, terminal cross-breeding and a new insemination protocol to develop large-scale insemination for smallholders.

- **Sexed semen**

[14] http://www.fao.org/in-action/fight-against-brucellosis-translates-into-action-in-georgia/en/

At the end of the 1980s, the USDA, the University of Colorado and a private company DakoCytomation discovered the technology of sexing of semen. This technology is now largely used by most advanced genetic companies, even though its cost is much higher than for conventional semen and results tend to be lower. In Georgia, sexed female semen could optimize the use of recently imported live animals as the needs are for milking female cows and not for bulls which can easily be substituted by artificial insemination, especially in large modern dairy farms where it should be systematic practice as in all advanced countries worldwide. With better trained inseminators and better management of their cows, it is expected that these farms will get good results with this technology.

- **Terminal cross-breeding**

The principle of artificial insemination is to improve step-by-step the genetic potential and performance of animals by using an improving breed (male) during various generations. Improvement of performance is strongest in the first generation (F1) because of the so-called heterosis (hybrid) effect.

If one single breed of male bulls is used during various generations, the fourth one (F4) will be considered a pure-bred calve from this breed. This approach is called absorption cross-breeding.

Another approach aims at keeping the qualities of both breeds, that of the initial mother cow and that of the male. In that case one generation will be inseminated with semen of a certain improving breed, and the second with usually local genetics. This approach is called alternate cross-breeding.

A third approach, slightly more sophisticated, is to have a circular system involving more than two breeds to get the highest heterosis effect at each generation. For instance in the US, highly-productive Holstein cows suffer from serious metabolic problems and have difficulties to reproduce. At the first generation, they are often crossed with Montbeliarde semen, and the Montbeliarde provide F1 their hardier genes with a heterosis effect. At the second generation, semen from Scandinavian Red is often used, also providing a heterosis effect. And for the third generation, semen from highly productive Holstein is again used. A recent study by University of Minnesota confirms the interest of this 3-breed rotation[15].

A fourth approach which could be very interesting to improve the performance of local breeds while keeping their contribution to biodiversity is “infusion” cross-breeding whereby an improving breed is used at first generation to provide a jump in performance, and then follow-up insemination is conducted with the local breed.

[15] www.thebullvine.com/news/comparison-of-montbeliarde-x-holstein-and-viking-red-x-holstein-crossbreds-with-pure-holstein-cows-during-first-lactation-in-8-minnesota-dairies/
and http://www.ansci.umn.edu/sites/ansci.umn.edu/files/procross_final_f1_first_lactation-kg.pdf

Finally, a leading technology is that of so-called terminal cross-breeding. Some genetic companies have selected Charolais or Belgian Blue bulls which are tested on the easy calving of their descendants. Here on the photo, this Belgian Blue bull has an excellent index for Easy calving of 114.

Terminal cross-breeding is used for insemination of poor quality cows whose descendants cannot be easily improved. It is usually used with dairy cows and allow them to get very good calves for meat. As these calves inherit the double muscle gene of the bull ("culard" gene in French), they are exclusively intended to be slaughtered, whether they are males or females, as this gene creates a serious problem for calving for the following generation. From there comes the appellation "terminal" cross-breeding. However cross-bred calves sell very well for meat as they have an excellent capacity to accumulate weight each day and a high carcass yield. The FinExCoop's team has successfully tested this technology with terminal cross-breeding Belgian Blue and Charolais in countries with poor genetics like Tajikistan without having any problem at calving. It will introduce it in Georgia as well.

- **New insemination protocol**

Traditionally, artificial insemination is based on detection of heat of cows by their owners. It is often associated with a modification in the behaviour of cows as in the following photos.

To identify and understand these signs on time is of cardinal importance to get positive results from artificial insemination and it requires well-capacitated breeders. There are unfortunately few of such breeders in Georgia where artificial insemination is just incipient.

A second key factor is that traditional insemination based on detection of heat implies to get a professional inseminator on time as insemination must be done around 12 hours after detection of oestrus. In Georgia where there are few experienced inseminators, and where the demand for artificial insemination remains limited, it creates a serious logistical bottleneck.

To deal with this bottleneck and create the pre-conditions for insemination on a large scale, FinExCoop will Test in Georgia an innovative insemination protocol based on the following technical steps:

1. Detection of pregnancy with the use of echography

The use of an ultrasound allows for checking pregnancy of cows in a much easier and more accurate way than traditional rectal palpation. Diagnostic of pregnancy can be done one month after fecundation against 3 months for rectal palpation.

2. Synchronization of heat with preparation of animals

If the echography shows that the cow is pregnant, there is nothing to be done but wait for calving. But if it is not pregnant, then the inseminator uses a protocol of synchronization of heat through a specific hormonal treatment which will make the cow ready for reproduction 9 days after. Prior to using this protocol of synchronization, it is usually necessary to treat the cow against parasites and to keep it away from bulls. FinExCoop will also promote the use of feed additives (oligo elements like copper or selenium and macro elements like calcium, phosphorus or magnesium) to improve the capacity of animals to react positively to artificial insemination

3. Insemination

With the combination of detection of pregnancy and synchronization of heat, a well-trained inseminator can potentially inseminate 30 cows per day with high levels of success. Consequently, this approach can allow dealing with the bottlenecks previously highlighted and helping introduce artificial insemination on a massive scale, especially with smallholders. Once they will have been convinced by numerous positive results of artificial insemination, they will be more willing to use this reproductive method and more aware of the signs of oestrus. At that stage, it will be possible to keep on developing the system using mainly the traditional method of detection of heat.

4) Improvement of local breeds through local selection

Worldwide, some decades ago, there was a massive shift from local breeds towards more productive global breeds, Holstein (the first breed in the world) in particular. Now, in most advanced countries, there is a reversing trend. In France for instance, Holstein still make in 2018 for 65.7% of total dairy cows, but their number is decreasing year-by-year contrary to that of Montbeliarde cows (17.9%). Normande cows make for 7.9% and have also seen a decrease in their number. Less productive regional breeds such as Abondance, Tarentaise, Vosgienne or Jersey experience healthy increase of their population from initially limited levels. In parallel, traditional regional breeds with very low productivity such as Flemish Red, Northern Blue, Ferrandaise, Black and White from Brittany have been saved from near extinction by conservation programmes supported by the State.

The French evolution is of much interest for Georgia as there are many similarities between both countries in terms of agronomic factors (role of mountains in particular and extensive approach of breeding) and use of milk (milk is largely consumed as cheese). French diversity of genetics for cows is without equivalent in the world with 12 breeds in official programmes of selection and 5 in programmes of conservation for dairy cows, and 9 breeds in programmes of selection and 8 breeds in programmes of conservation for meat cows.

In France, the promotion and protection of breed diversity is mainly linked to three factors which are also expected to play a key role in Georgia.

First, there is no good breed or bad breed in absolute terms. A breed is good in specific breeding conditions and with specific technical capacities of its breeder. Holstein are best in intensive modern conditions of breeding in cowsheds to produce larger volumes of milk. They are not adapted to long walking distances in mountainous pastures and they are not the best ones to produce milk for cheese. In Georgia, there is a need for cows which can easily walk in mountain pastures and for cows which can resist hot temperatures and high humidity. While Holstein make sense in modern farms where cattle is fed in cowsheds, they are not adapted to those two factors. In France, they are mainly located in the Western and Northern parts of the country with oceanic mild climate and are usually fed with silage maize and soya meal. Normande are mainly found in Normandy where they benefit from excellent quality grass in pastures. Abondance and Tarentaise are only found in mountainous areas where they graze in pastures. Montbéliarde are mainly located in mountainous areas but they are also developing all over the territory.

The adaptation of specific breeds of cows to specific breeding conditions, to specific “terroirs”, is recognized in France through its system of geographic indications (“Appellations d’Origine Contrôlée”, AOC), which is a key second reason explaining their diversity. The French law of AOC dates back to 1919 and its principles have been introduced in EU laws in

1992. The new Farm to Fork Strategy of the EU reinforces this approach[16]. The principles of geographic indications are also being replicated in Georgia where FAO and EBRD have recently implemented a project in the field together with the association of organic producers Elkana and consulting firm REDD[17]. In France, there are currently 45 AOCs for different types of cheese[18]. The biggest AOC in terms of volumes produced is that of Comté. As for other AOCs, its terms of reference combine three main requisites:

- Comté must exclusively be produced from the milk of two breeds, Montbéliarde or Simmental (they were the same breed until the end of the 19th century)
- The milk used for Comté must exclusively be produced from certain territories, most of them located in the mountainous range of Jura
- And cows must not spend all year long in cow sheds, they must have at least one ha each of pasture, they cannot be fed with silage and with GMO feed.

The same types of rules will most probably apply sooner or later to Georgia if the country wants to make effective use of its law on geographic indications. As its main comparative advantage for high quality cheese is its mountain pastures, it will need cows well adapted to this environment and to a feed base relying mainly on grass and hay as it is the case in France for Montbéliarde, Simmental, Tarentaise, Abondance, Vosgienne and other breeds used to produce most high value hard cheese in France, but as it is also the case with its local genetic resources.

A third reason of major importance for the diversity of cows in a country like France is the willingness of the French State to protect its national bio-diversity. Programmes of conservation of breeds with low productivity are being implemented and have yielded positive results. This genetic patrimony is a highly valuable public good which could eventually be mobilized on a larger scale as beyond the Covid 19 crisis human societies now understand their extreme fragility vis-à-vis pandemics for which specific genes of rare breeds could sooner or later be of use[19]. The gene bank of the world is of utmost importance for the future as 60% of human transmittable diseases come from animals. The more resilient these animals, the lesser risk of zoonosis and the lesser risk of transmission to humans as clearly pointed out by the One Health initiative.

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[16] "The Commission (…) will work with co-legislators to improve agricultural rules that strengthen the position of farmers (e.g. producers of products with geographical indications), their cooperatives and producer organisations in the food supply chain."

[17] FAO-EBRD Project "Support to Sustainable Value Chains through the Development of Geographical Indications (GIs) in the Dairy Sector"

[18] There are between 350 and 400 varieties of cheese registered in France, reflecting the extreme diversity of its territory which can also be found to a large extent in Georgia. General de Gaulle used to say: "How can you rule a country where there are 246 varieties of cheese?" He was forgetting many of them.

[19] Promotion of bio-diversity is a major axis of work of the French development Agency AFD that is implementing FinExCoop.

The active protection of biodiversity is also a major component of the EU Green Deal which includes a Biodiversity Strategy for 2030.

In Georgia, the local cows are not productive but they are fully adapted to their environment and resilient. According to the FAO, *Animal genetic resources of the USSR*, 1989[20], there were three main types of them at the end of the FSU, the Caucasian brown, which is not an endemic one as it was created in Soviet times by crossing the local Caucasian cattle with bulls of the Swiss Brown, Kostroma and Lebedin breeds, the Georgian Mountain cow and the Mingrelian Red which are both endemic Georgian cows.

The exact origin of the Georgian Mountain cows is not known. They are able to live in tough conditions and graze on pastures with a slope of 45%. The Georgian Mountain cows are very small: the live weight of mature cows is 220-280 kg and that of bulls is 270-370 kg (by comparison a Jersey cow will weigh 430 kg and a Tarentaise cow 550 kg, and they are the smallest Western European cows). They are black, black-and-white or red-and-white. The head is light, the neck thin and short, the back narrow, the chest deep, the udder small and glandular, and the skin thin and elastic. The basic measurements of mature cows are: withers height 100-108 cm, chest depth 53-56 cm, diagonal body length 120-126 cm, chest girth 139-142 cm, cannon bone girth 13-14 cm.

The average lactation period is 230 days, and calving interval is 380 days. Under extensive management conditions Georgian Mountain cattle have a low milk yield: it varies from 650 to 800 kg. The important property of these cattle is high fat percentage. The average fat content is 4-5%; the best cows produce milk with 6.2% fat. When they receive adequate feeding, they can produce up to 1,900 kg of milk.

These cows have a unique capacity to adapt to the high mountain grazing lands, to resist infectious diseases and acute changes of temperature.

The Mingrelian Red is mainly located in Western Georgia. It is bigger than the Georgian Mountain cow. The live weight of mature cows is 280-320 kg; bulls weigh 450-480 kg. Its colour is rust, brown and grey. The basic measurements of mature pedigree cows are withers height 110-115 cm, chest depth 58-60 cm, oblique body length 133-135 cm, chest girth 165-167 cm, cannon bone girth 17-18 cm. The milk yield on breeding farms is up to 2,000 kg with 4.4% fat and 3.7% protein. The best cows produce milk with 6% or more fat.

The Mingrelian Red cattle have the following qualities: they are adapted to outdoor management, they can withstand long-distance walk, they are able to exploit water-logged meadows in winter and poor alpine pastures in summer, they are adapted to the hot climate, and they have good resistance to diseases.

[20] Edited by N. Dmitriev, and L. Ernst, Soviet Academy of Agricultural Sciences.

FinExCoop will promote absorption cross-breeding of Georgian Mountain cows with Tarentaise cows, and absorption cross-breeding of Mingrelian Red cows with Jersey and Tarentaise cows. But it will also support the identification of best local animals to help put on track a selection and improvement programme for both breeds making use of best international technologies. In this programme, “infusion” cross-breeding will be initially used to improve the performance of the breed.

It is expected that both MEPA and its development partners, the EU in particular, will proactively engage in the promotion of “modern and competitive bio-diversity”, beyond what has already been developed through the recently completed FAO genetic improvement project for Georgia, Armenia and Ukraine.