ARGENTINE BEEF IS NOT PART OF THE PROBLEM: IT'S PART OF THE SOLUTION

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Why does Argentina produce sustainable beef?

As a country Argentina is committed to mitigating greenhouse gas emissions.

Five years on from the signing of the Paris Agreement (COP21), which committed the 174 signatory countries plus the EU to reducing their greenhouse gas (GHG) emissions, in 2020 the Covid-19 pandemic provoked a temporary reduction of between 5-10% in global emissions. This reflected the great importance of various human activities, such as industry, transport, electricity generation, and others, which all suffered a fall, while other activities such as cattle farming remained unmodified. This totally unexpected pandemic has revealed the need for far-reaching structural changes to limit the rise in average global temperatures to no more than 1.5°C over temperatures recorded in the pre-industrial period. Complying with that goal will entail decarbonising the atmosphere by moving the planet towards a net zero carbon economy, in which carbon emissions must not exceed mitigation efforts. Net zero carbon is the greatest challenge facing the international community at a time when climate change is the most severe threat to life on the planet. Another challenge is adapting to the effects of climate change, such as extreme events (droughts, floods, heatwaves), rising sea levels or the shrinkage of high-mountain glaciers that is affecting the volume of water in the rivers.

In response to the Paris Agreement, Argentina presented its goal of restricting its emissions to 483 Mt eqCO2 by 2030. In December 2020, it reconsidered its commitment and proposed to lower that goal to 358.8 Mt eqCO2, with the aim of reaching carbon neutrality by 2050.

By ratifying the UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC) Argentina assumes a series of obligations, such as implementing national programmes that contain measures to mitigate climate change and facilitate adaptation to it.

Under this convention, as of 2014 developing countries have the obligation to submit BIENNIAL UPDATE REPORTS (BUR) every two years. In the case of Argentina, the National Cabinet on Climate Change (GNCC is the Spanish acronym), created by decree 891/2016, is responsible for producing these reports. Its objectives include adopting policies on climate change and complying with the commitments arising out of the UNFCCC and the Paris Agreement.

These biennial reports contain updated information on national greenhouse gas inventories (NGGI), needs for technological and technical support and information on mitigation measures and the respective monitoring, reporting and verification methodology.

To date the inventory has been calculated using methodology defined in the Inventory Guidelines drawn up by the Intergovernmental Panel on Climate Change (IPCC) in 2016. In 2019 an update of these guidelines was published but has yet to be adopted by the UNFCCC, although it is certain to be used in the coming years. The next biennial report will be submitted in December 2021. Adherence to the 2019 guidelines is not compulsory, but the factors contained in the report can be adopted. In Argentina, the calculations will probably be made using the same guidelines as those used for the 2016 inventory. Nonetheless, any changes in the guidelines should not entail significant changes in the results (Galbusera, pers. com., 2021)

According to the Argentina 2016 inventory, cattle farming accounts for 16% of total national emissions, while enteric fermentation from cattle accounts for the highest proportion within the total emissions from agriculture, forestry and other land uses (AFOLU).

As regards the validation of these data, to a large extent tensions appear in the impact construction methodology and subsequent measuring.

The main criticisms levelled against these calculations by different sectors are:

- The possibility of carbon sequestration in meadows and natural grasslands not currently considered in inventory calculations is currently under discussion (Viglizzo et al., 2019; Villarino et al., 2020);

- The 2019 guidelines reduce the coefficients of nitrous oxide emissions from excretions of grazing animals (-80%);

- Various authors maintain that the presence of methane in the atmosphere is less than that of carbon dioxide in the soil, meaning that the conversion factor used to calculate the tonnes of equivalent carbon is lower.

Regardless of these criticisms, cattle farming accounts for a low level of emissions globally. Emissions from national cattle farming represent only 0.15% of the planet's total emissions.

[1] *AFOLU*

Factors of environmental impact.

The scientific basis for the environmental impact factors and their degrees of approach are key, both for establishing the international bases for negotiation and for ensuring the use of fair rules of play in private commerce.

After cutting through the multiplicity of facets to the issue, various important aspects of environmental impact can be mentioned: a) emission of greenhouse gases, b) carbon sequestration, c) water footprint, d) biodiversity and land conservation, e) preservation of forestry and ecosystemic services.

a) Greenhouse gas (GHG) emissions

Regarding other sectors of the economy that can only mitigate emissions by implementing far-reaching structural changes (by substituting renewable energies for fossil fuels, for instance, or by replacing materials, or completely redesigning processes), the cattle farming sector can mitigate emissions by natural processes that are respectful of nature. This is both a strength and an opportunity because it requires low financial investment, since it is more closely associated with process technologies rather than with input technologies.

The agro-livestock sector as a whole has adopted a series of new practices and has made substantial improvements, resulting in a 10% reduction in emissions compared to 1990, exceeding the commitment made under the Kyoto Protocol (signed in 1997), and a 26% fall from the maximum value recorded in 2010 (Moreira Muzio et al., 2019). As regards livestock, GHG emissions come from a variety of sources. Since 1990 they have reflected a downwards trend, explained partially by a reduction in the number of heads, but also by substantial improvements in the efficiency of the productive cycle. Emissions from Argentine cattle thus fell from 1620 kg of eqCO2 per head in 1999 to 1350 kilos of eqCO2 per head in 2016 (MAyDS 2019b). However, this positive evolution does not exempt the sector from making even greater efforts to control and reduce the principal sources of emission, especially enteric fermentation, and prevent CO2 losses through deforestation, or the disappearance of grasslands and perennial pastures. However, it is not enough simply to reduce emissions, but as mentioned above, the sector has an opportunity to act as a carbon measures required in other sectors, thus becoming an ecosystemic service.

In this respect, improvements in national inventories to account for the sector's real contribution to national emissions are a strategic priority. Another form of reducing emissions by the sector nationally is to use locally determined emission factors. This would make it possible to fine tune those values that are used by default in the estimates proposed by the IPCC guidelines, and to provide a number adjusted for local reality, which would allow identification and prioritisation of those areas where improvements must be made. This will improve the accuracy of the estimates both of inventories and of the carbon footprint (CF) of beef. In order to produce information locally, work must be done on strengthening, planning and investing in research in the country.

In comparison with other sectors, the future relative contribution of the cattle farming sector to GHG emissions may be lower. Internationally there is a discrepancy regarding the metrics to used calculate GHG rather than CO2, with particular emphasis on reviewing the real impact of CH4. Two arguments stand out: i) the lower mean life of CH4 in the atmosphere compared to CO2; and ii) the difference in CO2 resulting from the combustion of the carbon in fossil sources. In agroecosystems CH4 occurs in biogenic processes intrinsically linked to circular processes, while what is emitted is eventually reincorporated through photosynthesis. Therefore, if the total amount of methane does not vary year on year, there is no accumulation of GHG. This discussion can lead to a readjustment in the way CH4 emissions (the main GHG from cattle farming) are measured, however it will not mean the end of the livestock sector as a source of GHG emissions and will result in the sector contributing less in relation to other productive sectors.

It is rarely mentioned that around 90% of the CH4 emitted is deactivated in the stratosphere by a free radical found in nature called hydroxyl (·OH), which acts as a sort of "atmospheric detergent" that breaks down the methane molecule and converts it into water vapour and a harmless alkyl. A smaller portion of the methane emitted is likewise sequestered by soil, which changes our perspective of the problem, since nature itself helps to considerably reduce its gravity by being responsible for "cleaning" the atmosphere of this contaminating gas. (Viglizzo, E.F. and Ricard, M.F., 2019).

CH_4 gas does not last in the atmosphere as long as CO_2 (approximately 10 years against over 100). Consequently, certain recent papers have suggested that if CH_4 emission levels are kept stable, concentrations in the atmosphere should level off instead of continuing to rise, as happens with other long-duration GHGs. In that regard, the metrics traditionally used to estimate the warming power of CH_4 should be reviewed (Allen et al., 2018).

Argentina has a platform of cattle farming systems in environments that are able to produce a wide variety of products, such as pastoralist or feedlot beef, and standard or organic products with traceability, designation of origin, an organic profile, a particular nutritional profile, and various slaughter weights or degrees of fat cover.

Emissions from our country are low, since cattle breeding here is extensive in nature, with most production taking place in pastoralist systems.

Our production is grassland-based and occupies 95% of the cattle breeding area of the country, some 60 million hectares, with half of the total head of cattle located in the Pampa region, which covers around a third of that area.

Even with termination in pens and three or four months of fattening, the importance of the extensive system in Argentina lies in the fact that in pastoralist-based systems fodder in the breeding phase accounts for between 70 and 80% of the dry matter and the amount of energy consumed in the system.

Pastures in the temperate region support 60% of the bovine stock and are the basis for over 50% of the country's beef production. Natural grasslands and megathermal pastures complete the platform on which the rest of the stock and production is based. They are the backbone of the various variants and strategies to intensify and improve the competitiveness of cattle farming. That diversity of systems is gradually moving towards integration with other productions based on soil rotation, or combined (silvo-pastoralist) uses. Those characteristics confer attributes of sustainability on cattle farming thanks to its adaptive, complementary and flexible capacity.

On the question of digestibility, foraging resources are directly linked with carbon emissions (Beauchemin et al., 2011; Hristov et al., 2013 a, b, Ricci et al., 2013; Rooke et al., 2013). Generally speaking, C3 forage tends to be more digestible and produce lower emissions per unit consumed (McCaughey et al., 1997, 1999), although aridity also generates a loss of digestibility, lignification and an increase in fermentation emissions (Ominski et al., 2006). Differences in forage between environments are key in correctly classifying carbon emission levels in the systems. Various systems around the world are looking to produce estimates for models that best describe their reality (Chaves et al., 2006; Kennedy & Charmley, 2012; McCrabb & Hunter, 1999; Hunter & Niethe, 2009). The indices reported in the bibliography are not sufficiently accurate to allow the diversity of Argentine livestock systems to be classified according to their environmental footprints, particularly of carbon.

Cattle farming is the only viable alternative for production in areas with low-quality foraging resources, and there it acts as a digester of fibre unsuitable for human consumption. In that context, the vast majority of Argentinian cattle production has low dependency on external inputs, since the extensive breeding systems based on natural grasslands require little or no input or use of agrochemicals and fertilisers, or of feed not produced in the establishment. For this reason, several of the management technologies designed to improve or maintain Argentine cattle production in such environments agree on this point.

Although enteric emission of methane is a metabolic constant that is difficult to modify, there are technologies of proven effectiveness to reduce it and allow a feasible route to improving the quality of animal diets through greater digestibility of the foods consumed (Cottle, D. et al, 2011, Cottle, D. and Eckard, R., 2014, Benaouda et al, 2019, Hegarty, R. 2014; Black, J. L., Davison, T. M., & Box).

A fall in production of enteric CH4 can be achieved through various mechanisms, some directly related to diet management, its components and relations between them, and others to the use of additives in diets, such as methanogenesis inhibitors, electron or ionophore acceptors, bioactive plant compounds, dietary lipids, exogenous enzymes, microbial agents, defaunation and manipulation of archaea and bacteria from the rumen, and others (Hristov et al., 2013b, Pezo, D., 2019).

Likewise, it is possible to control methane and nitrous oxide emissions from effluent management in intensive systems (feedlots) by replacing open systems (troughs) – which make the reuse of nutrients and the generation of bioenergy difficult – with closed systems that facilitate the circular economy of these processes.

Any increase in productive efficiency is an opportunity for bovine livestock. Although improved efficiency does not necessarily reduce absolute emissions (e.g., if expressed per hectare), it is possible to reduce relative emissions (or carbon footprint) per unit of marketable product (e.g., per kg of beef or kg of animal protein).

Examples of improvement appear in the evaluations made by Faverin et al., (2019b), who modelled the application of good management practices for livestock systems typical of the Depressed Pampa and found a potential fall of up to 17% in the CF (calculated to the cattle gate), with strategies for the production and quality of the fodder, as well as for bringing forward the service age of heifers.

According to the research paper "Low-emissions development of the beef cattle sector in Argentina", published by the FAO and the New Zealand Agricultural Greenhouse Gas Research Centre in 2017, there are great possibilities for mitigating GHG emissions by employing different strategies to reduce their intensity. This could be further promoted by implementing public-private policies designed to increase productivity of the total head of cattle.

Another paper based on a modelling of cattle systems in the district of Laprida, province of Buenos Aires, reveals that if rearing in net breeding systems is included, a fall of 10% may be obtained in emissions of CO2-equivalent/kg of the daily gain in grazing systems compatible with a rational use of the resource. This would prevent overgrazing and allow an increase in daily weight gain in pastoralist systems and in average slaughter weights (Bilotto, F. et al., 2019).

Bovine genetics, balanced nutrition, feeding and grazing management are examples of four technologies that have proved to be effective in reducing the carbon footprint. In recent years Argentina has advanced with research into residual feed intake (RFI) in different cattle breeds and the possibilities of it being transmitted to their young. This would no doubt contribute to an improvement in the overall efficiency of our country's cattle farming system and a consequent reduction in emissions per kg of beef produced.

Feedlots and the use of waste from agro-industry.

The incorporation of feedlot technology improves management of the animal load and avoids the problems of overgrazing faced by other countries with fewer environmental resources. Likewise it allows for a more profound link with agro-industry, and a greater use of those by-products that would otherwise be discarded as agro-industrial waste. In that context, cattle farming has strengthened the link with agro-industry to make use of by-products, control transaction costs and investments, and make the most of short term opportunities. It is a keen user of agro-industrial by-products: from the processing and distilling of maize (gluten feed, distillers grains); from the extraction of soya and sunflower oil (expellers and high-protein flours not used in food for human consumption); from the processing of peanuts (skins) and from the barley, wheat and other winter cereals (bran and culm) industry; from horticulture (remains and peel from the cleaning and industrialisation of potatoes, carrots and beans); and from fruticulture (pomace, peel and discards of wet and dry fruit). The new generation of supplements for grazing animals or animals in feedlots has moved away from the classic format of grain and soy flour-based concentrate. The plan is for confined livestock to eat feed supplemented with a greater percentage of by-products from other agri-food industries. The by-products of bioenergetic systems tend to transform intensive livestock models (e.g., distillers grains in USA changed the production matrix of the feedlot).

The use of megathermal pastures and their environmental benefits

The incorporation of megathermal pastures has brought an improvement in receptivity and complete-cycle production in cattle-raising areas of greatest agro-ecological weakness, thus allowing improvement in the environmental recovery of degraded areas.

In regions with suitable agro-ecological conditions, the incorporation of megathermal pastures (e.g. Gatton panic/Megathyrsus maximus, Buffel grass/ Penisetum ciliare; Grama rhodes/Chloris gayana; Angleton grass and Nadi blue grass/Dichanthium aristatum and caricosum; Mulato grass/Braquiaria hibrida) has expanded the receptivity and the distribution of the supply of forage, and with it the opportunity to achieve greater production of calves per hectare, or to retain animals at the rearing stage, or even in seasonal fattening.

The incorporation of megathermal species has intensified over the past 25 years and has changed the structure of cattle farming in the north of the country. Receptivity has increased as has “complete-cycle” production, from breeding to fattening (SENASA and MAGyP reports, 2018). After natural vegetation, the pastures of introduced megathermal species are the most important foraging resource in the cattle farming systems of the North-East Argentina, accounting for nearly 20% of the total surface. This entails a reduction in the erosive processes associated with grain agriculture, a boost to the animal categories with the highest requirements of quality and improved management of low production lots and low primary productivity environments (Babera, 2018; Frasinelli and Venesiano, 2014).

In the Arid Chaco, the introduction of buffel grass in cattle farming systems means that forage production capacity in the most degraded areas can be restored in 2-3 years (Blanco et al., 2016; Avila, 2018). The INTA EEA La Rioja has developed and evaluated a bovine breeding system that envisages the sowing and introduction of buffel grass on 10 to 15% of the total area of the establishment to complement the use of natural grassland. Buffel pastures are used in the system during the months of spring-summer (October-March), coinciding with the calving and animal servicing season. Meanwhile, natural grassland is used in the autumn-winter months (April-September), the period of vegetation rest. The system also envisages management of the total herd adapted to the environmental conditions of the region.

Valdez (2017) concluded that grassland can be kept in a good condition by maintaining levels of beef production in breeding systems (north of Córdoba) in years of lower rainfall, and applying a technological package that combines a system of controlled grazing with the use of cultivated pastures and creation of forage reserves.

From a review of species, and the introduction and management of megathermal forage in Argentina it emerges that the information available, with its regional nuances, is a form of capital at the producer's disposal to extend the area of these species and improve their use (Namur et al., 2014; Borrajo and Pizzio, 2006; Borrajo, 2007; Perez et al., 1998; 2014; Nenning, 2014, 2016, 2018; Agnusdei et al., 2011; Pueyo and Nenning, 2011; Pueyo et al., 2019; Pons et al., 2017 a,b,c; Valdez et al., 2018; Rigalt et al., 2017; Mijoevich, 2018). In this regard, research conducted in Australia stresses the importance of incorporating subtropical legumes such as leucaena that contribute to achieving lower methane emissions, CO2 sequestration and nitrogen fixation in soil. This will ensure, increased forage production without the use of chemical fertilisers (Shelton, M., & Dalzell, S., 2007, Taylor, C. A et al., 2016).

Livestock farming technology and opportunities for improved emission mitigation

Argentina has a robust and diverse scientific-technological system and is recognised internationally for the training its professionals and livestock producers receive in applying new management techniques for grazing systems.

The generation of scientific-technical knowledge on GHG and livestock occurs not only through scientific and technical bodies, with researchers trained specifically in the subject, but also through civil associations of producers interested in responding to this challenge. The focus is on the design of strategies for mitigation and adaptation to climate change and on generating local reference values.

The sector recognises the need to mitigate farming emissions as one of the great current challenges it faces. Although the degree of recognition of the relationship between agricultural production and GHG is inconsistent and diverse there is growing interest in the productive sector in tackling the issue and making changes in the face of society's demands on environmental performance. This favours the design and implementation of good livestock practices that reduce the impact of production on climate change.

The technologies, practices and processes that can be incorporated into progressive (not regressive) cattle farming operations include animal stocking management and the intensity and frequency of grazing, the application of animal welfare protocols, land uses and practices that favour soil organic carbon sequestration, and restoration of degraded ecosystems (such as wetlands) that deserve to be recovered. In forested ecosystems the elimination of deforestation for sowing pastures is advisable, along with forestation and reforestation in silvo-pastoral systems. In the production of grains and fibres for animal feed the use of reduced tillage or direct sowing is suggested together with cover crops, minimal use of pesticides, precision fertilisation and improved sources of nitrogen fertilisers (coated urea, urease and nitrification inhibitors), and management of animal excretions and treatment of effluents.

Additionally, other mechanisms have received considerable attention recently, such as the use of vaccines, enzyme inhibitors in methanogenic microorganisms and the selection of animals with lower methane emissions (Patra, 2012). It should be borne in mind that the feasibility of application of each one must be the result of careful evaluation, first of the animal - more specifically of the gastrointestinal tract - and then of the total herd, in terms of its effects on productivity, the use of nutrients, expected costs and profits, which will ultimately determine acceptance by producers (Monteny et al., 2006; Martin et al., 2010).

One option being increasingly investigated is the use of ionophores. Ionophores, such as monensin and lasalocid (approved for use by the SENASA), and others more commonly used, act on the Gram-positive bacteria in the rumen, including producers of $H2+$ and formate, butyrate, lactate and ammonia. However, they do not affect succinate- and propionate- bacteria (Ramírez et al., 2014). All this prompts a fall in the production of $CH4$, acetate and butyrate, and an increase in the proportion of propionate in the rumen (Boadi et al., 2004). There is also a fall in the production of lactate in the rumen, meaning a lower risk of acidosis, a reduction in the deamination of the proteins present (Zeoula et al. 2008) and the loss of ammoniacal nitrogen in the urine (Callaway et al., 2003).

b) Carbon sequestration

Improvement in the sustainability of livestock occurs in two areas: a) a reduction of sources of GHG emissions, such as enteric CH4, or N2O principally from the urine of grazing animals or from manure management systems; and b) an increase in CO2 absorption from the atmosphere above ground (e.g., forestation) or below ground (soil organic carbon, SOC), in what are known as "nature-based solutions" (Smith et al., 2020; McElwe et al., 2020).

In 3/4 of the country cattle farming is the principal activity, or the only significant one. It is practised on surfaces that have low agricultural competitiveness, and over 80% of grazing lands have the potential to sequester carbon. However, the capacity of pastures and grassland soils to fix carbon is still too high.

As mentioned above, there is consensus on the potential of the agricultural-livestock sector to become an important CO2 sink. This is particularly true of the production systems based on pastures and/or with the presence of trees (whether silvo-pastoralist, native woodland or windbreaks). This presents the sector with a great opportunity, since carbon sequestration can partially or totally counteract emissions, or in some cases even exceed them, thus leaving a positive balance in terms of carbon accumulation. The challenge is to define how near or far from carbon saturation soils are, and so determine their capture potential and to what extent any capture can exceed, reduce or neutralise emissions from the productive system. Local information is required to appraise and adjust this potential to the country's various productive realities. Such information is currently lacking (Jacobo et al., 2020).

A carbon sink, CO2 sink or carbon reducer is a natural or artificial carbon deposit that absorbs the element from the atmosphere and helps to reduce amounts in the air. Terrestrial sinks, forest management and forestation have received the greatest attention, especially after the agreements made under the Kyoto Protocol. Taking stable soil organic carbon (SOC) into account is much more recent, with the studies made by the IPCC (IPCC, 2019b) and the FAO (2019) acting as a trigger. Estimates are that improvements in the management of grazing lands can mitigate between 0.3 to 3 gigatonnes of CO2eq per year globally (Smith et al., 2020). Additionally, incorporating carbon into the soils not only helps mitigate climate change but also generates agricultural improvements, such as increases in fertility, capacity for humidity retention and the structural stability of soils.

The important role of grazing lands as carbon sinks has long been underestimated (Viglizzo et al., 2019). In recent years different MRV (Measure, Report, Verify) systems have been implemented both by private sectors (e.g., Verra VCS Standard, Gold Standard), and by countries (e.g., Australia Gov. CFI, USDA's COMET Platform), or by international bodies (e.g., FAO, SOC, MRV). Since livestock activity requires fewer conditions of soil quality and fertility than agricultural activity, there is a long list of ecosystems under grazing that could act as carbon sinks, e.g., natural grasslands, pastures, integrated agriculture-livestock systems, silvo-pastoral/agro-silvo-pastoral systems and wetlands. In all of them soils are the main carbon sink because they capture CO2 in the form of SOC, but in some of them it is also possible to identify other aerial sinks, especially environments with native and introduced forests where carbon can be captured and sequestered as plant material in the tree layer (Peri et al., 2017).

Recent research into the carbon cycle has been looking into the question of environmental deterioration, where soil is key for its dual role in short- and long-term carbon sequestration and in CO2 emissions into the atmosphere. It is clear that SOC also determines soil quality in the biochemical and physical processes that permit the presence of aerial and subterranean biomass, which also acts as a carbon reservoir in terrestrial ecosystems (Fuentes et al., 2012).

The sink of soil organic carbon is almost three times greater than that contained in living beings or biota (1550 compared to 550Pg) (Lal et al., 1995). It should be remembered that Pg means petagram and that 1Pg equals 1 billion kilograms. Therefore, small increases in SOC could slow down the increase in CO2 concentrations in the atmosphere (Schlesinger, 1995).

In cattle farming systems managed on the basis of direct grazing, carbon entries depend on the net primary production of pasture or grassland, as does the ungrazed remainder that lies on the surface in the form of brushwood or litter, and on the decomposition of roots. In contrast, carbon escapes when it is exported as a product or in animal respiration.

The potential for soil carbon sequestration differs in terms of climatic conditions and the intrinsic properties of the soil. In general, the potential for carbon sequestration tends to maximise in situations with the greatest precipitation/temperature (mm/°C) ratio and with the highest presence of active clays (FAO, 2017). According to a global study by the FAO currently in development (Global Soil Carbon Sequestration Map), the estimated capacity of carbon sequestration in soils in the country varies between 0 and 0.8 tn C/ha/year. As regards livestock systems, this highly variable capacity for carbon sequestration may reach between 25% and 70% of "additionality" from projects generated by better grazing management systems, fertilisation and introduction of enhancing species (Peralta and Di Paolo, personal communication). The capacity for improvement is not restricted to the classic soils of excellent agricultural quality, but also to environments restricted by aridity or salinity, where scant attention was previously paid and where legumes play a significant role in improving soil quality and agricultural conditions as a result of their part in achieving a more balanced C/N ratio without contaminating.

Considering that our inventories and reports show a negative carbon balance for the Argentinian rural sector, a simple calculation consisting in hypothetically estimating a modest sequestration capacity of 0.3 tonne/ha/year of carbon in grazing lands (which, as mentioned, cover around 80% of the country) would reduce that imbalance and generate a small carbon surplus or credit. This simple exercise serves to demonstrate the importance of calculating carbon sequestration in the country's carbon balance (CB). It should be noted that this exercise only calculates the fraction of carbon retained as SOC, i.e., it omits the fractions retained in aerial biomass and subterranean biomass within the system analysed (Viglizzo, E. F. et al., 2019).

Recent revisions of the forms and methodology used to evaluate CB in the agrosystems of the Mercosur region reveal the important role of grazing lands in the net capture of carbon (Viglizzo et al., 2019; von Haden and Dornbush, 2017). That role is commercially valuable since it would justify cattle farming from the point of view of its environmental behaviour, rather than of the competitiveness of beef or the sociocultural implications of the activity. Incorporating such a role would provoke a paradigm shift with impact throughout the chain and in urban perception. As mentioned above, over almost the whole country the capacity of pasture and grassland soils to fix C is very high, except in cold environments with a high load of organic matter, and in forest soils with a high rate of oxidation of edaphic C (lateritic structure of the soil) and is seen as the largest carbon reservoir (Stewart et al., 2007). Associating livestock with grain agriculture and with instruments (ecoefficient perennial pastures) to capture C will be central in sustainable agro-livestock models (Gasparri & le Polain de Waroux, 2015). The system could reappraise pastoralist production centred on sustainability.

The abundance of grazing lands in Argentina presents both a strength and an opportunity, neither of which has received the attention they deserve, to convert the land into carbon sinks. All the practices and processes that promote plant photosynthesis potentially favour the capture and storage of carbon in (aerial and subterranean) biomass and in the soil. Fertilisation, the incorporation of pastures with leguminous plants, perennial pastures, cover crops, rotational grazing, the incorporation of different tree and bush species (silvo-pastoralist systems) are factors in the production system that stimulate the capture of carbon in the biomass and the soil. Part of the labile carbon in biomass can become a more stable fraction of carbon if incorporated into the soil; but that depends on the degree of carbon saturation of the soil and of other edaphic properties. (Eduardo de Sá Pereira et al., 2015, Galantini, J. A., & Iglesias, J. O., 2007).

It is interesting to analyse the network of weaknesses and opportunities that appear in a vast territory of semiarid and arid lands in Argentina. An important source of synergies and conflicts (trade-offs) occurs in grasslands and wooded areas that have been degraded by overgrazing, and have remained exposed to a secondary succession with growing participation of young trees and bushy vegetation. Although the cattle farming productivity of these lands is declining (which is not desirable), the expansion of areas of young trees of rapid growth and of bushes may trigger high rates of capture and carbon sequestration in biomass for certain periods of modulated time in the external environment. A considerable quantity of grazing land in Argentina meets these characteristics, and should be measured and evaluated more precisely for impact potential in national inventories, in the economy of the livestock enterprise and in the actual carbon economy.

Carbon gains from areas of young trees in grazed woody systems are often overlooked. However, in a recent paper in Nature (Cook-Patton et al., 2020), 13,112 geo-referenced measurements from areas of native woodland were studied, and the conclusion was that the factors provided by default by IPCC underestimate the accumulation of C in the aerial biomass of young trees by 32%. Many regions of our country, e.g., the large phytogeographic province of Espinal, composed of xerophytic trees and bushes that cover a whole central band of Argentina from NOA to La Pampa and SW of Buenos Aires, are subject to degradation from grazing. But remarkably there may be carbon gains through ecological succession that includes the appearance of areas of young trees that can act as sinks to mitigate climate change.

Science is the discipline that should orientate future research, and the development and adoption of practices and technologies. Cooperation between the private sector and State science and technology agencies, together with an intelligent communication strategy, is key in consolidating the competitiveness of cattle farming.

Social communication must be a vehicle to inform of demonstrable environmental progress, and to share a clear vision of knowledge and technology. This report demonstrates that with a knowledge-based strategy a lot can be achieved in a short period of time.

It would be highly desirable for the notion of "Zero Net Carbon", understood as carbon sequestration and storage, to equal or exceed the emissions produced by fossil fuels and biogenic processes (enteric process, animal excretions, plant decomposition), and become a goal within the National GHG Inventories that the government regularly produces.

At present, in order to estimate components of the CB use is made of international reference values, which are taken from compilations of international scientific publications made by IPCC. However, in many cases, such estimates were generated in very different systems to local ones, revealing a need to improve estimates of local emissions. By preparing data bases from internationally available data and with simulation models, it is possible to work on hypotheses of carbon sequestration in cattle farming areas to replace the uncertain idea of zero sequestration. It is thus necessary to invite the scientific community to generate patterns of probable carbon sequestration which, in practice, would imply a qualitative leap from Tier 1 to Tier 2 within the methodological guidelines proposed by the IPCC. It is also important to work on creating a robust data base of CH_4 and N_2O emissions in our cattle farming systems. This would allow not only improved estimates of CB, but also the inclusion in balances and in the national inventory of locally developed mitigation practices designed to improve the CB. This requires a research and development effort to generate robust local measurements that are reportable in the scientific literature, so that they can be validated for use at local level.

Additionally, these actions must be taken against a backdrop of adaptation to climate change, so it will also be important to increase response capacity to the negative effects of climate change (such as a greater frequency and intensity of droughts, floods, heatwaves) by designing and implementing measures adapted to the productive system.

c) Water Footprint

Since most of Argentina's cattle production occurs on natural grasslands with low to moderate loads, the water footprint is principally green, and coexistence between the native flora and fauna is possible. Moreover, maintaining certain plant cover produces benefits such as improved water retention and preservation of the content of organic matter in soil.

According to a preliminary report on the project "The water footprint in refrigerated cuts of Argentine beef", conducted by the INTI with IPCVA financing, in Argentina the inventory includes primary and industrial productive activity within total volumes, and 99.2% (16.10 m3) of the water consumed for the production of a kilogram of unboned packed beef corresponds to the so-precipitations and is used for crops. A further 0.6% (0.10 m3) corresponds to the "blue" footprint, which covers the use of well or mains water for life cycle operations. Finally, 0.2% (0.03 m3) of the footprint is "grey" and corresponds to virtual water required to dilute the pollutants in effluent. (Echazarreta & Tuninetti, 2019). These values are similar to those described internationally by different authors.

Only 14% of the total national herd is fed in confinement for termination prior to slaughter, and an additional 28% is fed in mixed grain-based systems. As a result, and as mentioned above, on average, 71% of the plant biomass consumed per live kg of production (complete cycle from birth) corresponds to grasslands and other native communities, while 21% corresponds to sown pastures, 5% to maize, 1.5% to oleaginous pellets, and 1.5% to sillage. The use of fertilisers and agrochemicals is practically nil for the production of forage from natural environments, and very limited in pastures and grazing land.

d) Biodiversity and land conservation.

On the best soils, livestock competes in the short term with agricultural uses, but in the medium term it complements them with rotation that helps to maintain the physical, chemical and biological properties of the soil. Moreover, together with agriculture, cattle farming produces diverse landscapes that help to maintain the biodiversity of native flora and fauna (favouring some species but negatively affecting others, and replacing the previous natural limits between biotic communities with fencing around different plots of land).

The biota of the soils contributes 25% to the biodiversity of the biosphere and is vital for recycling nutrients and primary productivity. The communities of arthropods, microorganisms (bacteria, archaea, fungi and protists), annelids and other invertebrates that live in the soil are essential in maintaining its fertility, and participate actively in the ecosystem as part of the trophic chain, either as decomposers or as food for communities of birds, amphibians, small mammals, invertebrates, etc. These underground organisms are crucial in maintaining the hygiene of the pastures, aireation of the soil and percolation of the water.

The largest cattle stocks coincide with the zones of greatest agricultural production, and agricultural and livestock rotations help to improve the sustainability of the soil and biodiversity.

Perennial pastures based on temperate leguminous and gramineous plants play a central role in the sustainability of national cattle farming. They have an impact on a region where 60% of the total national herd is found and where 75% of the beef is produced. Sharing the space with harvesting agriculture, and even after having ceded the best soils to agriculture, pastures in such environments are still the backbone of Argentinian cattle farming. Correct management of production from pastures and the ecosystemic services in those environments largely define the sustainability of cattle farming in the region with the highest stock and production in the country.

e) Preservation of the forestry resource and ecosystemic services

Argentina's silvo-pastoralist system (SPS) is responsible for much of the production on natural grasslands in regions outside the Pampas, where there is a suitable combination of forestry and grazing land on a surface of 34 million has.

A great variety of silvo-pastoralist systems exist in various different environments (e.g., Chaco, Patagonia, Mesopotamia, Delta) based on different species of trees and forage (Peri et al., 2016). This diversity of productive systems reflects differential spatial configurations in the search to increase animal production, and diversify products while sustaining the system (Peri et al., 2017). Of the total forested area, the greatest SPS activity with plantations is in Neuquén. Approximately 70 per cent of the ñire forests in Patagonia are of silvo-pastoralist use with little integral management in establishments. In Chaco, over 6 million hectares are turned over to silvo-pastoralist uses with varying degrees of intensity.

Various papers have evaluated variables in questions of pasture, animals and soil (Torres et al., 2014, 2016; Martínez Calsina et al., 2015, Corbella et al., 2015). In the INTA Leales, Tucumán, Rhodes Epica (Chloris gayana Kunt) grama pastures introduced into pastoralist systems in 2010, and white carob (Prosopis alba) in silvo-pastoralist systems were grazed by weaned Braford calves over 4 productive cycles (2011-2014) in the period between May until the following March (Martínez Calsina et al., 2015). The presence of the trees plus the pasture had a positive effect on the edaphic variables measured, on beef production and on the productive stability of the pasture. Between canopies there are competitive effects (Baldassini et al., 2018) that deserve to be studied to find the associations between forage species, control of the animal load and the animals' productive component. It is presumed that these models will expand over the coming years as they are economically viable. They are not particularly dependent on exogenous inputs, are compatible with environmental services, and the value of their products is rising.

As a country Argentina is concerned about deforestation, but it has faith in the measurements made of the situation, which reveal a gradual fall in deforestation rates in native forests in recent years.

In response to high deforestation rates, in 2007 National Law 26,331 of minimum standards of environmental protection for native forests (Forest Law) was passed. Together with other provincial laws and regulations on forests, it classifies the areas of native forests into 3 levels of protection: category I (red), category II (yellow) and category III (green). The main objective of this law was to promote forest conservation and management by regulating expansion of the agricultural and livestock frontier (García Collazo et al., 2013). Compared with the total remaining native forest in the country's various forested regions, the annual percentage loss of native forest fell since National Law No. 26,331 was sanctioned by approximately 0.9% annually to a minimum of 0.34% a year in 2015. However, after 2015 deforestation rose to an annual rate of 0.42% in 2018. The loss of native forest in the period 2007-2018 mostly occurred in the Parque Chaqueño region (87%), especially in the provinces of Chaco (14%), Formosa (13%), Salta (21%) and Santiago del Estero (28%).

However, in Argentina cattle farming was not the main reason for deforestation but was seen as a transition towards harvesting agriculture, or a combined model (agricultural-livestock farming) that has received little attention in terms of environmental risk.

The fall in the deforestation rate in our country has meant that natural habitats, biodiversity and carbon stock have been maintained thanks to appropriate regulation of the water cycle.

Beef production systems that include the presence of trees operate in Argentina and may well expand. The presence of trees permits an increase in the system's capacity for C sequestration. They provide shade and shelter for animals, thus contributing to their wellbeing. They also maintain microclimates by generating local clouds of atmospheric humidity due to evapotranspiration from the trees that extract water from deeper tables. In addition, they prevent hydric and wind erosion, promote plant and animal biodiversity, reduce air pollution and capture leachates. Moreover, the economic and financial results of the systems are higher since they are the outcome of two complementary activities.

Degrees of approach to environmental impact.

The different dimensions of the environmental problem can be approached on various levels and in varying degrees: from the pre-predial level (the manufacture of productive inputs), to the predial (production in the field) and to the post-predial (links in a chain from cattle gate to consumer).

The complexity of the issue also demands the need for an integral perspective on the cattle and beef chain (C&BC) represented by institutions and actors that define public policies and private strategies.

Figure 1 summarises the possibilities of intervening in the factors of environmental impact as regards the dimensions of approach and the three levels (pre-predial, predial and post-predial). These interventions may be classified as (i) of global interest, and (ii) of local interest. The first may directly affect international trade in bovine meat in the future, while the second has a bearing on domestic publications and may be the cause of social reaction.

The greatest indications of environmental impact that can be controlled by man lie in the management of bovine excretions (dung and urine) in the field, degradation of land from overgrazing, treatment of effluents in confined fattening systems and abattoirs, deforestation, the use of fire, habitat destruction, and biodiversity loss.

Figure 1. Dimensions of environmental impacts and areas of intervention in the C&BC

	GHG	Carbon sequestration	Loss of wooded biomass	Loss of ecosystem services	Loss of biological diversity	Contamination	Degradation of soil and water	Environmental sustainability of the system
Complete chain	Strategic intervention and certification of chain	Strategic intervention and predial certification	Education and communication	Best practice and communication	Best practice and communication	Monitoring and communication system	Best practice and communication	Best practice and communication
Post-Predial	Transport and processing	None	None	None	None	Transport and processing Effluents in meat packing plants	None	Waste management and recycling
Predial	Excretia N fertilisers and labour	Management of pastures and woody vegetation	Zero deforestation and forestation	Management of vegetation and wetlands	Management of vegetation and wetlands	Effluents management in fattening	Intensity and frequency of grazing	Increased efficiency and animal welfare
Pre-Predial	Manufacture of low carbon inputs	None	None	None	None	Manufacture of inputs	Manufacture of inputs	Type of inputs and management of discards

Global importance: all cells in the GHG column; Complete chain – Carbon sequestration; Predial – Carbon sequestration through Loss of biological diversity. Local importance: all other cells.

Source: Based on papers prepared under the RSA/IPCVA Agreement

The counterpart to these restrictions emerges from the ability of pastoralist systems to offer intangible eco-systemic services such as carbon sequestration, climate and water regulation, soil protection and habitat preservation for flora and fauna.

Environmental care as a factor of competitiveness

In years to come, the challenge facing Argentina's cattle and beef chain will be to strengthen its position in international markets. Traditionally its competitive base has been a diverse primary platform of livestock systems integrated into environments able to produce a broad variety of quality products, categories, slaughter weights and degrees of fattening. It is complemented by a varied industrial and logistical capacity to respond to market demand with a growing weight of exports.

As in every market, regardless of monetary and regulatory conditions, its competitiveness abroad basically reflects the productivity of the internal productive structure. Although it has solid bases, the structure has areas where improvements can be made (e.g., procreation rates, marketing systems, elimination of double standards) in order to consolidate recent actions and take a new global leap.

The current "window of opportunity" in the global market brings opportunities and threats forcing anticipatory and/or private and collective proactive actions on these new issues. Besides productivity, care for the environment throughout the productive process in the C&BC now appears as a strong factor in competitiveness. This is evident in eventual restrictions on exports and/or in differentiation opportunities that can strengthen it. However, environmental protection definitively forms part of the export agenda in supranational bodies like the United Nations (UN), countries and/or blocs of countries, "institutional" buyers and certain consumer organisations (mostly located in developed countries). Greenhouse gas emissions, care for the soil and the biota, the water footprint, biodiversity and eco-systemic services are increasingly being incorporated into international trade relations and are taken into account more and more in access conditions to different markets.

An influential paper published by the FAO (*Livestock's Long Shadow*, 2006) focused criticism on beef cattle by attempting to prove that it is responsible for around 18% of direct and indirect global greenhouse gas emissions. Various responses emphasised the questionable methodological approach used in measuring and the arbitrary way in which the conclusions were used to restrict exports. After intervention by the private sector, in 2013 the same FAO team revised the figure in a further publication (*Tackling Climate Change through Livestock*) and concluded that said percentage was 14.5%.

The Lancet published the “Eat Lancet” Project in 2007 in which it recommended consuming no more than 50g a day of ruminant meat to protect human health (from coronary diseases, cancer, diabetes, etc.) and the global environment.

Powerful non-governmental organisations (NGOs) support similar ideas. A recent book by Bill Gates (*How to Prevent Climate Change?)* maintains that rich countries should only eat beef that is 100% synthetic as a way of tackling the climate crisis, and through his foundation he proposes to encourage the production of proteins in laboratories as an environmental response.

Environmental issues have ever greater importance and the capacity to restrict and/or promote exports. Different arguments and justifications not exempt from vested interests now form a growing part of the commercial agendas of countries and enterprises.

In its 1992 “Rio Declaration” the United Nations Conference on Environment and Development enshrined a series of principles essential for sustainable development. One of them is the so-called “precautionary principle or approach”. When faced with specific work, or an activity with a potential negative impact on the environment, this principle allows for a political decision not to permit such work to go ahead based exclusively on indications of possible damage, without the need for absolute scientific certainty, thus giving rise to a discretionality that can lead, to non-tariff barriers to trade.

What are the “academic” reasons to intervene in foreign trade from an environmental perspective? It is suggested that the negative externalities generated in some productive spaces - GHG emissions, loss of biodiversity, contamination, etc. - are not included in costs/prices in private accounts. Therefore, it would constitute unfair or spurious competition for other actors operating in those particular markets.

On that basis, the existence of negative externalities - associated with the use of technologies and/or environmentally unsuitable productive processes - justifies actions to guarantee an appropriate assignation of resources. Translating the concept to international trade, some countries impose an “environmental charge”, while in others (or in the community as a whole) an “**environmental impact**” is felt. The imposition of taxes or other restrictions on trade is thought to restore commercial fairness.

This line of thought forms the conceptual basis on which a good part of the technical experts in regulatory agencies and policy makers establish their positions. It is then incorporated into international trade rules.

Additionally some authors suggest that compliance with environmental standards may be an argument to differentiate products, provided that differential sources of demand are willing to pay a surcharge on them.

So for one reason or another, the bulk of analyses and research papers agree that environmental requirements will clearly tend to become normal compulsory standards in the near future.

Less clear is the precise but restricted approximation to the concept of **environmental impact** possibly caused by an activity that uses ecosystems as a base, and has direct impact on them. The complexity and diversity of agricultural/agro-industrial production, transport and distribution logistics to reach the consumer may have multiple impacts. They may not be of the same kind (e.g., silvo-pastoralist livestock sequesters carbon simultaneously with the emission of methane, as described above), have different temporalities in their effects (e.g., the short-term impact of poor waste treatment) or cause imprecise “contrary effects”. They cannot readily be condensed into a few consistent easy-to-measure indicators.

Although traditional tariffs and non-tariff measures have been reduced as a result of multilateral negotiations and bilateral trade agreements, strong growth is being observed in non-tariff measures related to environmental care (ALADI, 2019; Loticci, Galperín & Hoppstock, 2013). This has led to an increased number of disputes notified to the Technical Barriers to Trade (TBT) Committee and the Committee on Sanitary and Phytosanitary Measures (SPS) of the WTO (ALADI, 2019).

Loticci, Galperín and Hoppstock (2013) claim that the increase in this kind of measures is a result of two characteristics: a) they are perceived as being of greater legitimacy by society; and b) they can be applied with greater discretionality than traditional non-tariff measures. It is principally developed countries that are adopting them with the probable intention of transferring to developing countries the costs of implementing the environmental obligations made under international commitments so as not to lose competitiveness, i.e., those countries seek to bypass the principle of Common But Differentiated Responsibilities (CBDR) (Green Pact, Green Deal, Farm to Fork).

Negotiated at the Earth Summit in Rio de Janeiro, 1992, CBDR is a principle enshrined in the United Nations Framework Convention on Climate Change (UNFCCC). The CBDR principle is mentioned in paragraph 1 of article 3 of the UNFCCC, and paragraph 1 of article 4.

The CBDR principle recognises that all states are responsible for tackling the challenges of climate change, but it concedes that not all countries have the same obligations or responsibilities regarding those challenges since the greater levels of industrialisation in developed countries imply that historically they have generated more greenhouse gases. This is a fundamental principle of the negotiations on climate change.

The intention of the developed countries to sidestep the principle of Common But Differentiated Responsibilities impacts directly in the conditions of market access in developing countries and is certainly more sensitive in the case of foodstuffs like beef.

Of the voluntary access measures that refer to the productive process those associated with environmental and/or ethical concerns of beef production throughout the value chain are acquiring greater importance. They include the Organic Seal, beef from grasslands, environmental and/or social responsibility certificates and animal welfare requirements. Likewise, the demand for this kind of requirement has grown with the incorporation of "new generation" environmental measures more directly linked to climate change that are currently under analysis. These measures are the carbon footprint, the water footprint and the environmental footprint, which under the form of ecolabels seek to provide consumers with information on the environmental impact of the product life cycle (ALADI, 2019).

The concept of carbon footprint is even being succeeded by the development of broader methodologies concerning the environmental footprint. Besides considering greenhouse gas emissions, the environmental footprint seeks to measure impact on biodiversity, natural resources and use and management of water, among other criteria (Loticci, Galperín & Hoppstock, 2013; Lottici, Daicz & Galperín, 2016). The problem that has been posed regarding these indicators is the lack of uniformity of methodologies that can be applied in measuring (ALADI, 2019; Lottici, Daicz & Galperín, 2016).

It was hoped that ISO 14067 would be published as an international standard to harmonise the different existing methodologies. After years of work and discussion, with the participation of 56 countries, it was not possible to reach the required consensus in the final stages of the process. The standard remained as a Technical Specification (ISO/TS 14067) or guideline that companies were free to adopt (Frohmann and Olmos, 2013).

The EU is currently advancing in the development of a harmonised methodology for calculating the environmental footprint, based on the precedent of the Grenelle II Law in France on the carbon footprint (Lottici, Daicz & Galperín, 2016). Regarding the commercial impact of this footprint, in 2011 Argentina presented criticisms of the Grenelle II Law to the Committee on Technical Barriers to Trade of the WTO, based on the fact that this kind of eco-labelling would imply higher costs and an administrative tax for producers in developing countries, which would have a negative impact on exports if it became a compulsory requirement (Loticci, Galperín & Hoppstock, 2013)

Even though the EU has considered the need to analyse the environmental footprint with a sector-specific and product-specific approach, there is concern over whether it can advance without an internationally agreed definition of environmental footprint that takes into account the characteristics of the productive systems and value chains of developing countries, to avoid making compliance difficult and discriminate against their products (Loticci, Galperin & Hoppstock, 2013). A study on the trade impact of the environmental footprint on Argentine exports to the EU conducted by Lottici, Daicz and Galperín (2016), with data from the 2011-2014 period, discovered that the main exports that could be affected are those related to beef, followed by wines, fish and animal feed. Of the exports of meats which could potentially be harmed, 95.4% are of unboned bovine meat, fresh or refrigerated beef (90.4%) or frozen beef (5%).

One particular aspect linked to the question is the environmental certification of the processes involved in the cattle and beef chain. Calculation of the indicators used is not internationally unified, and different private consultancy firms authorised to operate in global markets have developed their own methodologies that do not necessarily coincide with those of other certification companies. This presents a difficulty for beef exporting countries when they attempt to develop environmental indicators based on their own procedures, which are not always recognised by certification companies.

Besides "the academic" aspect, scientific bases are crucial in designing environmental indicators and certifications that may affect the C&BC business. Hence using the environmental problem as an argument to restrict trade can lead to serious trade disputes in which we can find genuine arguments for spurious restrictions. As explained below, international negotiations must be based on science-based public standards, and not private standards.

The market perspective

How are these issues projected onto international trade, in which an environmental variable can be generated in a local space but may eventually have global impact? Restrictions appear on three planes:

Supranational. Led by United Nations initiatives, a baseline of indicators is set to identify the initial situation, establish criteria for the formulation of indicators, specify the goals to reach in the future, and set the commitments countries will assume. An example is the national mitigation commitments agreed at the Conference of the Parties (COP) in Paris 2015, and later events. Adhering to these agreements sets precedents and establishes commitments for future evaluations of behaviour. Argentina committed itself to a goal of GHG emissions which, given the prevalence of livestock production in the country, implies recognition of the problem and unavoidable adjustment for the C&BC.

One important issue which is highly likely to occur is extending environmental requirements to international transport. In this case, "supranational" entails probable modifications that may seriously affect the meat trade given that eventual remediation measures, i.e., reduction of navigation speeds, change of fuels, etc., can affect both the profitability of the activity (it is transferred to tariffs), and the carbon footprint and life cycle analysis (LCA) of beef.

There are other actions and agreements that countries have committed to that may restrict international trade in our products (e.g., forestry policies and laws designed to protect native forests, preservation of biodiversity, protection of wetlands, the fight against desertification, etc.). They all involve agreements signed by countries in different scenarios and forums.

Generally speaking, agreements between countries and/or blocs of countries on specific products contain environmental constraints. Those established supranationally are taken as parameters and are applied – after interpretation- to specific cases. The vast majority of these standards are influenced by European and American parameters. Based on the "European Green Pact" initiative and the "Farm to Fork" strategy, the EU increased environmental access requirements to their markets, with beef as one of the most vulnerable products exported to the bloc. Regardless of WTO demands, in a scenario of weak multilateralism, this situation will require strategic work by the private sector in coordination with public bodies in order to avoid losing market positioning.

Nevertheless, Brexit presents opportunities for the Mercosur countries to sign agreements with good prospects for beef. In fact, in its "hard exit" scenario from the EU, the United Kingdom could become a net importer of South American beef.

Likewise, as mentioned above, as an important country in the supply of animal protein to satisfy growing world demand at an effective rate, the United States also demands safe food. In recent years the country has made good progress in producing sustainable beef.

Specific agreements between private economic actors establish conditionalities on environmental and social sustainability. Similar factors operate for the trade in beef and by-products processed according to religious/ethnic norms. The most relevant are: a) strong pressure (and some specific actions) to exclude products from areas of recently felled native forests; b) growing requirements associated to the concept of animal welfare; c) consumers in the ABC1 segment who demand more information on environmental impact and traceability, health (nutritional composition of foods, compliance with animal welfare protocols, animal health and product safety) and social conditions (child labour, slave labour, fair trade).

Additionally, private certifications in destination markets are increasingly becoming barriers of access for companies in producer countries for various reasons: a) they are not always based on scientific criteria; b) they implicitly penalise exports from less developed countries by evaluating environmental or employment criteria that are incompatible with regulations in force in these countries; c) they present great diversity between countries, even between marketing channels, so therefore they stray from the search for regulatory harmonisation and convergence at international level; and d) their private nature means they are not regulated by States and are excluded from negotiations on trade liberalisation. Important production standards are included in the GLOBALGAP protocol, which is being increasingly required from their South American beef suppliers by supermarkets and distributors.

One market niche in which certain environmental issues are ever more important and which is under particular examination is that of Halal and Kosher meat, purchases of which are made according to religious protocols. Environmental aspects (expressed generically and open to interpretation when implemented) are taken into account in operations protocols.

Environmental impact of transport in international markets.

As mentioned above, an increasingly important issue on agendas is the effect of transport systems on GHG emissions.

The growth of international transport of merchandise has sparked concern over the control and reduction of GHG emissions generated by this sector. Recently goals have been agreed for reductions that will have an impact on the competitiveness of exporting countries according to distance to destination markets (International Transport Forum - OECD, 2018).

A reduction in greenhouse gases emitted by maritime transport is under discussion at the International Maritime Organisation (IMO). In April 2018 an action plan was agreed to reduce total GHG emissions by at least 50% of 2008 levels by 2050. The strategies proposed to improve efficiency in transport and port activities include optimising speed, using a higher proportion of ecological fuels and fostering development of new technologies (Galperín, et al., 2021; Galperín & Leon, 2019).

An important change in environmental regulations occurred at the start of 2020 when the use of very-low sulphur fuel oil, or the installation of catalytic convertors was required to help reduce GHG emissions. Although this measure led to an increase in costs and prices, the impact was not as great as other factors affecting demand for transport, such as purchase decisions in China (Fredricks – MSC, pers. comm.). Measuring the carbon footprint and having policies to reduce it is key in the competitiveness of companies in the sector.

Care for the environment from the consumers' viewpoint.

In addition to the legal and operative restrictions/protection resulting from the consideration and application of the precautionary principle, another series of aspects related to consumer preferences can be considered. Consumers base their decisions not only on price and income but also on their perceptions and points of view regarding the environment.

Society's perception of the responsibility of livestock production in climate change has assumed an unprecedented dimension, which influences consumer choices and preferences. This is due in part to primary production being further and further from the end consumer, who is increasingly alien to the productive process.

Some consumers have begun to replace beef with other meats, or are choosing plant-based diets, due to the negative image they have of aspects other than the nutritional attributes (e.g., animal welfare, climate change, deforestation, etc.). Consumers build their image of a product on information that is readily available, and not on information from the product source. Although it is true that the information they receive may be biased, erroneous or incomplete, the reality is that eating habits are changing, along with consumers' motivations when choosing products. Changing people's perceptions requires a greater insight into the interests of consumers and improvement in the communication strategies used to transmit the qualities of a product.

The demand for food is changing. New buying habits have emerged along with the consumption of healthier products that are more respectful of the environment and animal welfare, changes that have accelerated due to the Covid-19 pandemic. Such changes can be addressed by all the actors in the food chain to reduce the associated "carbon footprint". The use of sustainable energies and new packaging materials and the development of business models inspired in the circular economy and a commitment to the environment are the most effective changes in the plant and animal production phase.

The change towards healthier, more sustainable eating must involve better relations between the actors in the chain in order to achieve more efficient food governance (Martinez-Alvarez et al, 2021).

We live in an increasingly sophisticated and complex society, and have moved from a rather passive consumer - who eats what is available - to a consumer who is confronted with an enormous variety of options, either on-line or in restaurants, and ever more numerous opportunities for consumption. These phenomena make information more necessary than ever and stimulate greater interest in what we eat. We should never forget that even as a consumer product, food is a repeated feature of day-to-day life (consumed at least three times a day in our societies). It is also subject to a series of intangibles, such as culture, territory, family and perceptions.

The idea of sustainability is closely linked to a product's ethical values, and here we could include a set of different social demands that are increasingly reflected in a desire to know what there is behind a product. Here we can mention questions such as child labour, deforestation, support for non-governmental organisations of an environmental, social or assistential nature, respect for minimum labour standards established by the International Labour Organisation (ILO), hydric and carbon footprints, and other issues (González Aleman, H., 2018).

The relevance of these changes to the consumer and subsequent interventions in the market deserve to be viewed from two angles: a) the existence of verifiable restrictions in specific cases; and, b) the presence of a potential risk to exports (and their legal protection) that can be activated when market conditions so demand.

In recent years gradual changes have been occurring in the habits and preferences of consumers of food.

The health-related habits of consumers are ever more important. They tend to aspire to a healthy diet that is low in sodium and carbohydrates and rich in fibres and proteins (Bagul, Koerten & Rees, 2019). In principle, the trend towards greater consumption of proteins offers opportunities for the cattle and beef chain as a natural supplier of proteins.

Similarly, in consumption patterns, more social concerns are evident over the impact of bovine meat production on two levels:

- The impact of these activities on the environment;
- Issues related to animal welfare (AW), (OECD-FAO, 2020).

The most important results of a survey carried out by the European Consumer Organisation (BEUC) in 2019 on attitudes of European consumers to sustainable foods confirm what was stated above concerning the future behaviour of demand in developed countries. In a report designed to bring information to the debate on public policies under the "European Green Deal", this organisation concludes that food is the leading driving force behind the environmental impact made by the average citizen of the EU. They consider that an important part of the food-related environmental impact in the EU is "included" in the agricultural products and food imported from third countries. However, it is unlikely that consumers will know of this "commercial footprint", which is certainly difficult to assess. It is worth remembering that in these issues the EU and USA act as modellers of trends.

They recommend that food companies provide the consumer with more and better information on production methods and the origin of raw materials to help eliminate false claims of sustainability, and also to give greater visibility to reliable labels (e.g., organic, fair trade, etc.). The BEUC proposes that consumer organisations perform a key role in evaluating and comparing labels to identify which to trust (European Consumer Organisation, 2020).

In August 2020 the BEUC published the results of a survey conducted between October and November 2019 in 11 UE countries (Austria, Belgium, Germany, Greece, Italy, Lithuania, Netherlands, Portugal, Slovakia, Slovenia and Spain) along with 12 of their member organisations. The aim was to investigate consumer attitudes to sustainable food in order to provide information for public policies in the "Farm to Fork" programme of the "European Green Deal". A 10-point questionnaire was given to panels of over 1000 respondents per country. The key results included in the report are:

I) Consumers tend to underestimate the environmental impact of their own eating habits, although they have a certain awareness of the impact of eating habits in general.

II) Consumers tend to view products obtained in a way that is respectful of the environment as being synonymous with "sustainable". They should be free of GMO and pesticides and be from local producers, with aspects that are specific to certain countries.

III) Over half of consumers say that concerns over sustainability have some influence (42.6%) or considerable influence (16.6%) on their eating habits. Price, the lack of information and the challenge of clearly identifying sustainable food options, as well as their limited availability, are the main barriers to the consumption of sustainable foods.

IV) Two thirds of consumers are willing to change their eating habits for environmental reasons. They want to waste less food at home, buy more fruit and vegetables in season and eat more foods of plant origin.

V) Just over 40% of consumers say they have stopped eating red meat, or have reduced their intake over environmental concerns.

VI) Although those surveyed claim to have little appetite for insects and "cultured meat", consumers are more likely to consider vegetable-based "hamburgers" (if made without GMO) and traditional vegetarian foods, such as legumes, as alternative sources of proteins.

VII) Over a third of consumers (38.9%) would support regulations forcing farmers and food producers to comply with stricter sustainability standards. Even more (53%) agree that farmers should receive incentives (e.g., subsidies) to produce foods more sustainably.

VIII) Most consumers (57%) think that it should be obligatory for food labels to provide information on sustainability. However, the idea of taxing less sustainable food is not very popular with consumers (only 1 in 4 agrees that less sustainable foods should pay more tax).

IX) Finally, consumers expect their governments to take the lead in promoting production and consumption of sustainable food. They also want the EU to remain firm as to its current level of ambition on questions of food sustainability, regardless of whether other countries around the world are doing the same.

As a future trend, with the change of preferences resulting from environmental and nutritional concerns and the rise in vegetarian or vegan life styles, a progressive reduction in the participation of red meats in diets can be expected, rather than total elimination.

This has given rise to various terms in the industry such as "flexitarian", a term used to typify those consumers who reduce the amount of meat in their diets and increase consumption of products of plant origin (Bagul, Koerten & Rees, 2019). The choice of a more "flexitarian" diet (deliberately eliminating meat from a number of meals) is thought to be the result of a series of incremental changes in behaviour over time. Instead of seeing animal proteins as basic foods and making purchase decisions exclusively based on price, the adoption of an "eat less but better" model is predicted (Bagul, Koerten & Rees, 2019; Capper, 2020).

Forecasts speak of an increase in demand for foodstuffs that comply with both environmental sustainability criteria and corporate social responsibility, a growing trend worldwide. According to a 2017 report on the global future of foods by Accenture Strategy, 73% of consumers would change a food brand they usually eat for another that is able to demonstrate its social commitment (Isabella & Coitiño, 2019).

Another aspect of consumption patterns identified in the global demand for beef is the influence of the generational factor. International surveys reveal the need to consider the preferences of millennials (24-41 years) and centennials (18-23 years) (Sánchez-Bravo et al., 2020). Compared with previous generations, these groups attach greater relative importance to whether the product is natural and/or organic, to its environmental impact and to animal welfare. This change in consumer preferences is an opportunity for greater segmentation in the food industry and is leading to important transformations in value chains (Gauna et al., 2019; Sánchez-Bravo et al., 2020).

Beef markets are growing in complexity due to considerable brand efforts and to the development of niche markets of different types of consumers (ODEPA, 2016). Some studies identify constant growth in markets for beef fed with a pastoralist and organic base, with little use of antibiotics (Drouillard, 2018). A sustained increase in demand for organic meat is forecast in EU, USA, Canada, Japan, Australia, Korea and China. In the case of China, the highest increase is observed in the gourmet markets of the country's mega cities (ALADI, 2019). Consumer knowledge of the issue is fairly poor and the terminology is confusing: consumers tend to mistake pastoralist production systems for organic production systems or conventional systems, making greater communication efforts by suppliers necessary (Stampa et al., 2020).

Regarding other niche markets of consumers with religious preferences, an increase in demand for Halal beef due to growth in the Muslim population, and a boost for Kosher meat are also predicted (CEI, 2019; ODEPA, 2016).

However, short- and medium-term prospects are not uniform throughout the world. In Europe and North America, consumption of beef and animal products is slowing. In these developed countries, where consumption levels are relatively high, slowing demand for beef is the result of saturation in per capita consumption levels, but also partly due to consumer perceptions on health and the environment (European Consumer Organisation, 2020; OECD-FAO, 2020).

For the next ten years (2020-2029) stabilisation in per capita consumption levels of beef in high-income countries is predicted with a rise in dietary preferences for higher-quality meats. In contrast, in emerging and developing countries, beef is rapidly replacing other foods since the growing middle classes can now afford what was once a prohibitively expensive food (OECD-FAO, 2020).

As a correlate, a scenario is expected of increased demand for access to international markets, represented by: a) stricter obligatory standards on food quality and safety; b) a move from product standards to process standards; and c) the growing importance of private standards (CEI, 2019; Gauna et al., 2019). Although private standards clearly differ from those established by governments, in this case it is necessary to move towards certification mechanisms and audits validated and supported by scientific information to prevent discretionalities in commercial authorisations which favour just a few in the business world.

As a consequence of the COVID-19 pandemic, the FDA (US Food and Drug Administration) estimates that there will be greater changes in the food system over the next 10 years than in several past decades. In fact, many of the challenges that have emerged during the pandemic have hastened actions on food security. The FDA has drafted a plan for the next decade called “New era of more intelligent food security” which rests on four pillars: technologies for traceability, more intelligent tools for prevention and response to outbreaks, new business models and retail modernisation, and a culture of food security (Franco, 2020).

Consumer perceptions will become more important and provoke a transformation in the functioning of the cattle and beef chain on questions of sustainability, traceability and formality with the support of the digital media (Buckart et al., 2020; Cunha Malafaia, Nogueira Biscola & Teixeira Dias, 2020). Providing consumers with information on animal welfare, environmental impact, the origin of foods and the possible risks of production will make the productive process important in securing market quotas (Buckart et al., 2020).

Ecosystemic services and carbon markets.

Demands to place a value on ecological goods and services have increased exponentially over the last decade in response to a worsening of the planet's environmental problems, and to public opinion that is increasingly sensitive to value. Many current programmes and projects (e.g., development, territorial organisation, investment, credit, etc.) in both developed and developing countries are not viable since they often omit an ecological and environmental perspective, i.e., the loss of ecosystemic services. In various regions of the world today a growing number of agreements and contracts govern the supply/demand ratio according to ecosystemic services, and the price to pay for them. However, this is exclusively dependent on a free market that generates regional disparities that have little to do with real biological value. The need for objective valuations is heightened as global society demands more consistent parameters rather than purely economic ones (Viglizzo et al., 2011).

In terms of the different factors of environmental impact addressed, market demands can be segmented and aligned with different regulatory conditions. Some EU countries are interested not only in a high-quality commodity, but also in intangible attributes associated to the system and the method of production, as well as patterns of emission and carbon sequestration, carbon footprint, preservation of native forests, ecosystem services and biological diversity.

On a more general note, due to the need to limit the increase in mean global temperatures to no more than 1.5°C over that of the pre-industrial period, the **carbon economy** is now a priority on the global agenda.

As mentioned above, in other sectors of the economy, such as the industrial sector, that can only mitigate the effects of climate change through changes in the physical process, our country's bovine sector can reduce emissions through biological processes in harmony with nature.

On a larger scale, the Argentine Pampa, located in the great Del Plata region, the epicentre of MERCOSUR activities in South America, is probably the least sensitive region to the transformation in environmental costs, compared with the Pantanal and Cerrado regions (Viglizzo & Frank, 2006).

Against this backdrop, Argentinian livestock must be prepared to adapt to the dominant trends within a new global carbon economy which opens possibilities for pastoralist production systems. To do so, sectoral leadership must resort to science to guarantee the transparency and responsibility demanded by the livestock business.

Carbon pricing is the intervention tool that enjoys the greatest consensus when it comes to internalising the externalities in economic activity associated to climate change. Therefore, it is vitally important to understand the carbon pricing mechanisms currently being implemented and planned for the future, and the effects on Argentina's economic activities in general and its beef exports in particular. Carbon pricing is a widely-used concept in the private sector, in national and international bodies and in academia, as a tool to reduce emissions and encourage investment in clean technologies. There are different forms of carbon pricing, the main ones being (World Bank Group, 2020):

- Carbon taxes: Taxes that explicitly set a price for carbon.
- Emissions Trading Scheme (ETS): Regulated bodies assume obligations to comply with GHG emissions, and they can trade with emission permits to fulfil said obligations. The two main mechanisms are: the cap-and-trade system and the baseline-and-credit system.
- Results-based climate financing: Funds granted by the provider of climate financing to the recipient, once a set of climate results is achieved.

The number of national carbon pricing initiatives that have been implemented, or are under study for future implementation, have increased in recent years. Carbon pricing mechanisms are present in all continents. The Emissions Trading Scheme (ETS) is the largest multinational trading scheme for greenhouse gas emissions in the world and is a cornerstone of the European Union's climate policy under which European Union Allowances (EUA), granting the right to emit a tonne of CO2 are issued. Ever since the first transactions, prices of the EUA ETS have been extremely volatile. Several factors affect price levels, such as growth of the economy, energy prices, and the total number of certificates and political decisions. Current values are around 40 euros per tonne and are close to historic highs. Various analysts of these markets foresee price rises, which could reach USD100/tonne with any sharp increase in restrictions.

Account should also be taken of the fact that the so-called "voluntary markets" or unregulated markets for carbon are consolidating, and are seen as an option. These markets take into account the agreements between private bodies beyond the national or supranational regulation mechanisms.

Eventual sales of carbon credits by livestock companies to international buyers (e.g., oil companies) that have made mitigation commitments should also be evaluated.

Currently, the most controversial approach to encouraging developing economies to reduce their CO2 emissions is a frontier carbon tax on imports from countries without adequate carbon pricing systems. However, there are different opinions about whether these taxes are effective in reducing global warming. Although a global carbon pricing mechanism is a long-term solution, other policies are necessary for developing countries to achieve their goals of reducing emissions. An additional problem for the effectiveness of this kind of measure is uncertainty in the calculations of emissions generated. Different methodologies can produce very different values for emission indicators.

This issue will be a priority at COP26 to be held in Glasgow (Scotland) in November 2021. In accordance with article 6 of the Paris Agreement, there will surely be definition on the future bases for a regulated market of carbon bonuses. In practice this may mean that carbon is viewed as an additional commodity which, together with meat, can be supplied by our country's cattle farming system.

Recommendations to strengthen the environmental competitiveness of Argentine beef

Such recommendations can be grouped according to two strategic topics. Some of the important actions are:

Topic 1. Induction actions to change operations routines to primary and industrial production routines that can mitigate environmental effects:

a. Reinforce the development of the estimation model for carbon capture to include different sinks;

b. Promote massive use of good livestock practices;

c. Establish a programme of continual improvement in environmental management in meat processing plants;

d. Have environmental certifications based on scientific knowledge generated in our country;

e. Continue reducing deforestation in accordance with the legislation in force; reinforce the declining trend in recent years by incorporating the massive use of satellite and other complementary technologies; establish a reliable scheme to measure overall evolution in this area.

f. Mobilise provincial strategies to adapt zoning and improve the application of the law of forest and shrub management.

g. Develop proposals to adapt systems to internationally valid and auditable C neutral models.

h. Stimulate the production of heavier animals for slaughter and an increase in minimum slaughter weight (progressive scale).

i. Stimulate inclusion of livestock in bioenergy production systems and the use of cattle by-products.

j. Stimulate livestock rotation and the development of silvo-pastoralist systems.

k. Promote designs to include biodiversity corridors in territorial planning in the provinces.

l. Promote the use of remote sensors, systems of geographical information and simulation models for evaluating foraging resources and the factors that make their efficient use difficult.

m. Improve animal genetics and incorporate genetic progress as an instrument to increase the hereditary basis of productive efficiency. An animal with superior genetics and greater efficiency in converting food into meat emits less CH4 per kg of beef produced. Genetics is a good tool to massively improve production efficiency at all levels of the production system (breeding, rearing, termination) and in all regions of the country.

n. Modulate ruminal fermentation, such as the use of ionophores, electron receptors, ruminal bio-hydrogenation, CH4 production inhibitors. Although some inhibitors have the potential to reduce enteric CH4 emissions, certain technologies are at incipient stages of development with few products that can be used in the short or medium term (e.g. 3-NOP, Bovaer® - DSM).

o. Use renewable energies (solar, wind, biological). This will entail substituting fossil fuels and may be a viable technological alternative in all links of the beef chain that involve energy consumption.

p. Improve efficiency in the use of pastures, shorten the idle period of wombs, increase the weaning percentage, establish a good breeding rate and improve conversion efficiency in feedlot systems.

Topic 2. Strengthening of measuring and evaluation systems for environmental impact (at sectorial and/or corporate level):

a. Intensify livestock sustainability in terms of the ecosystems/ environments in which it occurs. The relative weight of the structural components, the threats and opportunities, change from region to region.

b. Follow up the design guidelines for the indicators suggested by certain supranational bodies (e.g., FAO) and review in terms of local productive realities;

c. Coordinate and centralise the various analytical work under way in the different local science and technology institutions and other spheres of knowledge generation; harmonise results and future actions with greater coordination;

d. Help to identify vacant areas in the issue analysed and give coverage by means of public/private programmes;

e. Invigorate a network to evaluate carbon dynamics in different livestock systems, with the aim of discovering the C balance and critical points for improvement.

f. Study productive land sparing-land sharing strategies that will allow a greater balance between production and environmental impacts.

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