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# Climate Change and Livestock Production

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**ABSTRACT:** Raising the global problem of climate change is important, due to the social and economic repercussions on the world population and natural resources. Understanding and knowing the logic of climate change and its repercussions, as well as socializing this knowledge, is vital to raising awareness of the need for a cultural change in the ways of producing and living in society. Climate change is a product, mainly, of high emissions of Greenhouse Gases (GHG), emitted in the productive and social activities of human beings. To properly understand this global problem, we begin with the approaches, diagnoses, evaluations and reports of the UN, ECLAC, FAO, WHO, WHOSA, among others; whose assessments and estimates have been oriented towards the low effectiveness of mitigation actions; The temperature on the planet has increased almost 0.18°C each year since 1981. At the national level, the reports of the Ministry of the Environment and Natural Resources (SEMARNAT) were analyzed, named *"Updating the National Inventory of Gas Emissions and Greenhouse Compounds, 1990-2019"*; and the report prepared by the National Autonomous University of Mexico (UNAM), called *"The State and Perspectives of Climate Change in Mexico: a Starting Point"*; as well as the temperature reports from the National Water Commission (CONAGUA) and the National Meteorological Service (SMN), which coincided in the progressive increase in temperature in Mexico. Livestock farming is part of this problem, at the same time it suffers the consequences of global warming. It emits just over 14% of GHGs and suffers the consequences, mainly droughts, causing a high mortality of livestock, particularly in the north of the country, which could cause a lower supply of foods of animal origin that would threaten food security.

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The guiding question of the study was posed in the following terms: what has been the impact of livestock production on climate change and what has been its contribution to this global problem; Is it decisive and definitive in the emission of GHGs?

The main objective of this study was to identify and review the participation of livestock in climate change. To do this, a literary review of relevant information and data on the topic was carried out, selecting that which was relevant to the study and that allowed explaining and interpreting the forms, characteristics and properties of the object of study.

As an implicit and latent objective, the identification of information was sought that would make possible the sum of efforts so that, from this forum and from the productive action of livestock farming, it contributes to a culture of respect and improvement of the environment; as well as expanding the frame of reference of the global problem of climate change and contributing to generating human awareness and collaboration in the promotion and acquisition of a commitment to access the right to live in a healthy environment.

*"Climate change"* is understood to be what is established in article 3 of the Mexican General Law of Climate Change (LGCC), *"[...] climate variation attributed directly or indirectly to human activity, which alters the composition of the global atmosphere and is adds to the natural climate variability observed during comparable periods [...]"* (LGCC, 2012).

The concept of climate change includes two components: a) global warming and b) greenhouse effect. The first refers to the increase in the global average temperature on the Earth's surface since the industrial era and is related to the "greenhouse effect" and the gases that generate it (GHG); The greenhouse effect *"[…] is of natural origin and necessary for life on the Earth's surface. The upper layers of the atmosphere are composed of certain gases (mainly CO2) called 'greenhouse gases' (or GHG) that absorb part of the energy emitted by the ground, as a result of having been heated by radiation from the sun. Without this effect, temperatures on the surface of the planet would fall by around 30ºC, making life as we know it impossible"* (Ihobe. Sociedad Pública de Gestión Ambiental, 2013).

GHGs, according to article 3 of the LGCC are *"[…] those gaseous components of the atmosphere, both natural and anthropogenic, that absorb and emit infrared radiation […]".*

Climate change is a present (and surely future) reality throughout the world, in whose development anthropogenic actions have been decisive, which, combined with natural causes, have caused climatic variations on Earth (constant increase in global temperature). The UN considered climate change as *"[…] a global emergency that goes beyond national borders. This is a problem that requires coordinated solutions at all levels and international cooperation to help countries move towards a low-carbon economy"* (UN, s/a)

The National Institute of Ecology and Climate Change (INECC, 2018) stated that *"[…] Carbon dioxide concentrations have increased by 40% since the pre-industrial era due, first of all, to emissions derived from fossil fuels. and, secondly, to the net emissions derived from land use change*[1]*. The oceans have absorbed around 30% of the anthropogenic carbon dioxide emitted, causing their acidification".*

To understand the logic of climate change and the participation of livestock, the international and national frameworks are proposed, which outlined the guidelines and orientations to face the environmental problem of planet Earth, and propose how and in what way livestock has contributed to this problem; as well as, identify the impacts that climate change has had on livestock farming.

**International climate change framework**

During 1992, the United Nations (UN) created an organization called the United Nations Framework Convention on Climate Change (UNFCCC), whose framework for action was *"[…] to establish the bases for action joint international agreement regarding mitigation and adaptation to climate change […]"* and its objective was stated in the following terms *"Achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference in the system climate. That level should be achieved within a sufficient timeframe to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and allow economic development to proceed in a sustainable manner."* (Mexico in the face of climate change (s/a).

In the document *"Mexico before climate change, s/a",* it was stated that *"[…] Mexico signed the Convention on June 13, 1992 and ratified it before the UN, after the unanimous approval of the Chamber of Senators, the march 11, 1993."*

The Kyoto Protocol was adopted in 1997, but did not enter into force until 2005. *"[…] It was created to reduce greenhouse gas (GHG) emissions that cause global warming. It is an instrument to put into practice what was agreed in the United Nations Framework Convention on Climate Change. […] In addition to the mitigation commitments of developed countries, the Kyoto Protocol promotes the sustainable development of developing countries. Mexico has fifth place worldwide in the development of CDM (Clean Development Mechanism) projects in the areas of methane recovery, renewable energy, energy efficiency, industrial processes and waste management, among others"* (SEMARNAT, 2016).

The Paris Agreement, which came into effect in 2016, was a legally binding agreement that determined the commitment and responsibility of 193 countries to reduce GHG emissions; set three long-term goals: *"a) substantially reduce greenhouse gas emissions to limit global temperature rise this century to 2°C and strive to limit this increase to even more than just 1.5 °; b) review countries' commitments every five years, and c) offer financing to developing countries so that they can mitigate climate change, strengthen resilience and improve their capacity to adapt to the impacts of climate change"* (UN, s/ to).

[1] Land use change refers to the removal of vegetation cover for other uses, the most common being urbanization and human settlements; as well as deforestation (Santillano, M. L., 2017).

The UN (w/y), stated about these objectives that *"The operational details for the practical implementation of the Paris Agreement were agreed at the United Nations Climate Change Conference (COP24) in Katowice, Poland, in December 2018, in what is colloquially called the Paris Rule Book, and were finalized at COP26 in Glasgow, Scotland, in November 2021."*

In 2015, the United Nations summit approved the so-called 2030 Agenda, which was integrated with 17 Sustainable Development Goals (SDGs) and 169 goals, among which were those related to responding to climate change and maintaining natural resources. (FAO, 2020).

The 2030 Agenda for Sustainable Development, including the 17 SDGs, are global objectives that succeeded the Millennium Development Goals on January 1, 2016 and whose evaluation was carried out in September 2019, at the High-Level Political Forum[2] where noted that the world is "off track" towards meeting the SDGs; It was reported that the world would not meet most of the SDG targets (FAO, 2020).

The UN (2021) estimated that to date it has not been possible to raise *"human development indices with a minimum ecological footprint […] The effects of climate change and the loss of biodiversity are increasing."*

Similarly, the Economic Commission for Latin America and the Caribbean (ECLAC, 2023) stated that *"[…] the 2030 Agenda for Sustainable Development agreed in September 2015 by the United Nations General Assembly […] to the half of the agreed period […] is not advancing at the desired pace. A good part of the indicators are outside the trajectory that would allow the goals to be met in 2030."* The reasons are attributed to the Covid-19 pandemic and the low economic growth of the region *"[…] 2023 will mark ten years of average annual economic growth of 0.8%, less than the 2.0% of the 'decade'. lost' of the eighties of the 20th century."*

In relation to SDG 13 Climate Action, ECLAC proposes as a diagnosis that *"[…] The countries of the region contribute relatively little to greenhouse gas emissions. However, they face high vulnerability to climate change. Between 5 and 10 million people in the region, on average, are affected annually by a disaster related to climate change, mainly droughts, floods or extreme storms […]"*.

The UN World Meteorological Organization (WMO) indicated that by 2021 the Planet had exceeded more than 1.0°C since the pre-industrial period. Since the 1980s *"[…] each new decade has been warmer than the previous one "[…] global annual temperature has increased at an average rate of 0.08°C per decade since 1880 and an increase of 0.18°C since of 1981 […]"* (CONAGUA-SMN, 2022)

The International Energy Agency (IEA) of the Organization for Economic Cooperation and Development (OECD), published in september 2023, the roadmap for the global energy sector, which it called the *Net Zero Roadmap*.

In this roadmap, the *"net zero emissions scenario"* was proposed; that is, with the use of low-emission technologies and an effective reduction of emissions, the aim is to achieve zero net CO2 emissions by 2050, particularly from the energy sector, which has the highest levels of GHG emissions (IEA, 2023).

This report stated that carbon capture technologies and credits have not been effective in the fight to remove CO2 from the atmosphere; On the other hand, renewable energies have been more effective. The cost of using solar, wind, heat pumps and batteries has decreased by almost 80% between 2010 and 2022 (IEA, 2023).

The report concluded by saying that *"relying on hydrogen and carbon capture technology hasn't really solved much, meaning the world should dedicate efforts and funding to the expansion of renewable energy. Clean energy capacity will need to triple worldwide before the end of this decade to avoid further warming […]"* (IEA, 2023).

**National climate change framework**

In 2022, Mexico published a report on the Update of the National Inventory of Emissions of Greenhouse Gases and Compounds, 1990-2019, as a signatory country of the UNFCCC, in accordance with article 12 of the Convention protocol and article 74 of the General Law on Climate Change (LGCC) of Mexico (SEMARNAT-INECC, 2022).

[2] The United Nations High-Level Political Forum on Sustainable Development was created as the central intergovernmental forum for global monitoring and review of the 2030 Agenda and its 17 SDGs; replaces the United Nations Commission on Sustainable Development and provides political leadership, guidance and recommendations for the implementation, follow-up and monitoring of this agenda (UN, 2020).

In this report, GHG emissions and absorptions by sources and sinks were estimated for the four emission sectors defined by the Intergovernmental Panel on Climate Change (IPCC)[3]: a) energy; b) industrial processes and product use; c) agriculture, forestry and other land uses and d) waste (SEMARNAT-INECC, 2022).

The emission of GHGs are the main causes and precursors of the increase in temperature and global warming, among which are mainly carbon dioxide ($CO_2$), methane (CH4), nitrous oxide (N2O), among others. others.

CO2e, or carbon dioxide equivalent, is a common unit for comparing various GHGs; These gases, individually, have different global warming potentials (carbon dioxide has 1, methane 28, and nitrous oxide 265). Converting these potentials to CO2e, using conversion formulas, provides a single and common reference for expressing global warming potential. CO2e is now the most common way to express "emissions" (SEMARNAT, 2020).

Carbon dioxide emissions ($CO_2$) refer to the release of this gas into the atmosphere, whether for natural or anthropogenic reasons. It absorbs radiation and prevents heat from escaping from the atmosphere. Its excess is what produces the global warming, along with other gases such as methane (CH4), nitrous oxide (N2O), which are considered the main GHGs; There are others such as water vapor, chlorofluorocarbons (CFCs) and tropospheric ozone (O3) that cause this effect (The Planet App, 2020).

The gases mentioned above are calculated with a unit of measurement in tons and the $CO_2$ equivalent or $CO_2e$ is used as an indicator to determine the carbon footprint. *"[…] As? The mass of the gases emitted is measured by their $CO_2$ equivalent to generate the greenhouse effect. For example, this equivalence tells us that 1 ton of methane (CH4) produces as much greenhouse effect in the atmosphere as 25 tons of $CO_2$."* (The Planet App, 2020)

The main GHG is carbon dioxide with 67%, followed by methane with 24%, and nitrous oxide, with 6%; the rest corresponds to "F" gases (HFC, PFC, $NF_3$, $SF_6$)[4] (SEMARNAT-INECC, 2022)

According to the Ministry of Environment and Natural Resources (SEMARNAT) and the National Institute of Ecology and Climate Change (INECC) (2022), *"GHG emissions in the country amounted to 736.6 million tons of $CO_2$ equivalent ($MtCO_2e$)[5] in 2019 […], of which the greatest contribution is due to electricity generation activities with 23.3%, followed by motor transportation with 18.5% and cattle farming with 13.2% […]"* $CO_2$ absorptions were 201.94 million tons, so net emissions were estimated at 534.66 $MtCO_2e$.

The same report from SEMARNAT and INECC (2022) established that carbon dioxide ($CO_2$) is the main GHG, which decreased in 2019 by 7.56% compared to 1990; presented a greater increase in 2016, due to the increase in the country's energy demand and the use of motor transport vehicles. *"[…] Methane ($CH_4$) emissions are mainly produced by the enteric fermentation and handling of livestock excreta, fugitive oil and gas emissions, the final disposal of solid waste, and the treatment and disposal of wastewater. During the historical series, emissions of this pollutant have had a growth trend (48.4% compared to 1990), although this has been less pronounced than that of $CO_2$. Nitrous oxide ($N_2O$) emissions are mainly due to the use of fertilizers, the management of excreta, and the treatment and disposal of wastewater. Like methane, this gas has had moderate growth (45.35% increase compared to 1990) and less than that of $CO_2$. "Hydrofluorocarbons (HFCs) showed a growth of 2,757% in 2019 compared to 1990, mainly due to the increase in the use of refrigeration systems and air conditioning."*

[3] The IPCC (Intergovernmental Panel on Climate Change) is the scientific group assembled by the United Nations to monitor and evaluate all global science related to climate change. Consulted at https://www.nature.org/es-us/que-hacemos/nuestra-vision/perspectivas/ultimo-informe-ipcc/#:~:text=IPCC%20significa%20Panel%20Intergubernamental%20sobre,different% 20aspects%20of%20change%20climate%C3%A1tic.

[4] Fluorinated greenhouse gases (F-gases) are a group of chemicals that contain fluorine. They are divided into four main categories: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6) and nitrogen trifluoride (NF3). Consulted at https://www.linde-gas.es/es/products_and_supply/refrigerants/environment_and_legislation/global_warming_legislation_hfc_control/index.html#:~:text=Los%20gases%20fluorados%20de%20efecto,productos%20qu%C3%ADmicos %20que%20contienen%20fl%C3%BAor and https://espanol.epa.gov/la-energia-y-el-medioambiente/emisiones-de-gases-fluorados#:~:text=En%20general%2C% 20the%20gases%20fluorinated, for%20activities%20of%20being%20human.&text=They%20dividen%20into%20four%20categor%C3%Adas,%20nitr%C3%B3geno%20 (NF3).

[5] MTCO2e (metric tons), a unit of measurement for carbon emissions, is a standard measurement that takes into account multiple greenhouse gases, such as carbon dioxide, methane and nitrous oxide; all greenhouse gas emissions are converted into the amount of carbon dioxide that would cause equivalent warming. (AWS, s/a, consulted at https://docs.aws.amazon.com/es_es/awsaccountbilling/latest/aboutv2/ccft-overview.html).

In Mexico, during the period 1990-2019, the increase in total net emissions was 24.69% (140,807.24 Gg[6] $CO_2e$) *"[…] this was mainly due to the increase in the categories of enteric fermentation, manure management and direct emissions of $N_2O$ of managed soils"* (SEMARNAT-INECC, 2022).

In October 2023, the National Autonomous University of Mexico (UNAM, 2023) published a report called *"The State and Perspectives of Climate Change in Mexico: a Starting Point"* which addressed the current and future impacts of climate change on the agriculture, biodiversity, water, health, energy and the economy. He emphasized the need to develop strategies and policies for adaptation, mitigation and transformation of the climate crisis (Estrada, F.; et. al, 2023).

The report maintained that *"Global change has diverse manifestations today, both in climate and pollution, loss of biodiversity, energy transition and food sustainability […]"* It was mentioned that *"[…] during the period 1975- 2021, the country showed warming rates of 2ºC to 4ºC per century in much of its territory. The different databases agree that the observed warming rates have been greater in the north of the country (HadCRUT5, GISSTEMP, CRUTS4.05[7]). According to the ERA5[8] analysis data […]"* The northern part of the country reached the highest warming rate in the same period (6ºC) and the southeastern region reached 5ºC (Estrada, F.; et. al, 2023).

Regarding annual precipitation, the UNAM report shows that the country's average *"[…] has increased at a rate of 3.1 (2.4-3.8) mm/month per century since the beginning of the 20th century. Climate change has modified the distribution of precipitation between the seasons of the year with significant increases in summer and autumn […] precipitation has decreased in northern regions of the country and has increased in the center and south."* (Estrada, F.; et. al, 2023).

Under a current GHG emissions scenario, the temperature increase could exceed 5ºC in 2100. If the commitments made *"[…] by the countries participating in the Nationally Determined Contributions (NDC; similar to SSP245) are met, the average annual temperature in Mexico could be limited to 3ºC compared to the period 1986-2005 […], if the objectives expressed in the Paris Agreement were achieved (SSP126), the average temperature in Mexico could stabilize at around 2ºC by the end of this century"* (Estrada, F.; et. al, 2023).

For their part, CONAGUA and the SMN reported the temperatures reached from 2015 to 2021 with respect to the average temperature of the period 1981-2010, in the following terms:

| Year | National average temperature | Temperature above average | Observations |
|---|---|---|---|
| 2015 | 22.1 °C | 1.1 °C | *"Warmest year, along with 2014, since 1971".* |
| 2016 | 22.4 °C | 1.5 °C | *"This new record surpassed by 0.4 °C the years 2014 and 2015, which had previously been classified as the warmest".* |
| 2017 | 22.6 °C | 1.6 °C | *"For the fourth consecutive year the national average temperature has been ranked as the warmest on record since 1971".* |
| 2018 | 22.2 °C | 1.3 °C | *"Despite the warmth of 2018, this year did not rank as the warmest year that occurred in the previous three years, 2015 to 2017; However, the trend of temperatures above the average of the last 15 years of the 21st century continued".* |
| 2019 | 22.4 °C | 1.5 °C | *"This value continues the trend in the increase in average temperature since 2011".* |

[6] 1 Gg of CO2 is a unit commonly used in emissions inventories, where it is also considered equivalent to 1,000 tons of CO2, that is, 1 Gg of CO2 = 1,000 T CO2 (SEMARNAT).

[7] HadCRUT5 is a gridded data set of historical global surface temperature anomalies relative to a reference period from 1961 to 1990 (accessed at https://www.metoffice.gov.uk/hadobs/hadcrut5/). GISSTEMP surface temperature analysis; estimation of global surface temperature change (viewed at https://data.giss.nasa.gov/gistemp/). CRUTS4.05, climate data set generated in the United Kingdom for the period 1901 to 2020 (viewed at https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.05/Release_Notes_CRU_TS4.05. txt).

[8] ERA5 is the ECMWF fifth generation reanalysis for global climate over the last 8 decades (viewed at https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview ).

| | | | |
|---|---|---|---|
| 2020 | 22.4 °C | 1.4 °C | *"This year was ranked alongside 2017 and 2019 as the warmest year according to the historical record since 1953. In addition, the year 2020 was placed within the category of warm and dry years".* |
| 2021 | 22.2 °C | 1.2 °C | *"It ranked as the fourth warmest year in the historical record since 1953; thus, adding one more year to the trend of annual temperatures above average".* |

**Source: table prepared based on information from CONAGUA-SMN. Annual reports 2015-2021.**

The previous table allows us to observe an increasing trend in the average annual temperature compared to the period 1981-2010.

Every year since 1991, new records for warming ocean waters have been reached. Between the years 2015 to 2021, the highest temperature values were reported, according to the global climate report from the United States National Center for Environmental Information (CONAGUA-SMN, 2022).

**Impacts of climate change**

The Pan American Health Organization (PAHO) and the World Health Organization (WHO) (w/y), stated that *"[…] Health is and will be affected by climate changes through direct impacts (heat waves, droughts, severe storms and sea level rise) and indirect impacts (respiratory and vector-borne diseases, food and water insecurity, malnutrition and forced displacement)."* It is estimated that by 2030, there will be an additional 250,000 deaths worldwide from climate-sensitive diseases, such as heat stress, malnutrition, dengue and malaria.

For ECLAC (2015) climate change constitutes a global negative externality, from an economic perspective; stated that economic activities emitted GHG into the atmosphere, causing economic, social and environmental consequences and pressures.

The impacts of climate change are and will be inequitable; There are strong risks, especially in low-income countries and social groups with fewer resources, since they are considered more vulnerable and with a lower capacity to adapt (INECC, 2018).

Between 2000 and 2019, extreme natural disasters induced by climate change cost $2.8 billion dollars.
The global cost of extreme weather events attributable to climate change amounted to $143,000 millions per year; it affected 1,400 millions people (González, F., 2023).

The INECC (2018) stated that "*The accumulated costs of climate change for Mexico during this century would be comparable to losing between 50% and up to more than 2 times Mexico's GDP in 2010";* furthermore, the greatest impact would be in urban centers, since the increase in temperature could reach up to 8º C by the end of the century due to the presence of the phenomenon known as *"heat island."* Furthermore, it could increase the costs associated with the presence of heat stroke diseases between 62 and 100%, gastrointestinal diseases between 10 and 12%, and vector-borne diseases between 25 and 31%.

The cost of flooding, states the INECC (2028), would be approximately 130 million dollars and estimates that by 2080 the cost would increase to 2 billion dollars per year.

It is estimated that around 68% of the population and 71% of GDP in Mexico are highly exposed to the direct negative effects of climate change (INECC, 2018).

**What happens to livestock?**

The Food and Agriculture Organization of the United Nations (FAO, w/y) estimated that global livestock farming emits 7.1 gigatonnes of CO2e per year, which represented 14.5% of all anthropogenic GHG emissions. Livestock (for meat and milk, manure and draft power) is the animal species responsible for the majority of emissions, representing around 65% of emissions from the livestock sector.

Food production and processing and enteric fermentation of ruminants are the two main sources of emissions, accounting for 45 and 39% of total emissions, respectively. Manure storage and processing account for 10%. The rest is attributable to the processing and transportation of animal products (FAO, w/y).

In Mexico, beef cattle emitted approximately 43.5 million tons of CO2e per year, with a population of just over 36 million heads by 2022 (SIAP, 2022), 1.21 tons of CO2e were emitted per head that year. (Jurado, P.; et. al., 2022).

Methane emissions ($CH_4$) were produced by the metabolic processes of ruminants; These *"[…] methane emissions associated with enteric fermentation in 2019 were estimated at 82,287.31 Gg $CO_2e$, which show an increase of 9.93% compared to 1990 […]"*; which constituted 95% of the enteric fermentation of bovines (SEMARNAT-INECC, 2022). One ton of methane is equivalent to 25 t CO2e (Jurado, P.; et. al., 2022).

Although livestock activity is not the main cause of GHG emissions, it is part of the environmental problem and is integrated into the indicators called *"Environmental Footprints",* which allow us to know the impacts (positive and negative) generated by the economic activities in the environment. The environmental footprints are the following: a) Carbon Footprint, b) Water Footprint and c) Ecological Footprint (UPB - Medellín Central Headquarters, s/a).

Carbon Footprint refers to *"[…] the totality of GHG emitted as a direct or indirect effect of an individual, organization, event or product [...]"* (ECLAC, 2010). While the Water Footprint refers to the use and origin of water, an indicator of the volume of water used in production; the origin is "green water" (rainwater); "blue water" (surface and underground water) and "gray water" (polluted water) (Mexican Institute of Water Technology, 2019). The Ecological Footprint is one that allows us to know social impact on the environment; *"It is a tool to determine how much land and marine space is needed to produce all the resources and goods that are consumed, as well as the surface area to absorb the waste that is generated […] The ecological footprint of each human being is 2.7 hectares. However, our planet is only capable of giving each of its inhabitants about 1.8 hectares [...] in Mexico, the ecological footprint calculated in 2006 was about 3.4 hectares per person [...] This difference indicates that each Of us use more space to cover our needs than the planet can give us […] The activities that have had the most impact on the growth of the global ecological footprint are the burning of fossil fuels, agriculture and livestock"* (SEMARNAT, 2017 ).

In the case of livestock production, the Carbon Footprint and the Water Footprint constitute the most important indicators that contribute to global warming; the Carbon Footprint as it emits GHGs, particularly methane ($CH_4$), the Water Footprint in the use and origin of water for animal production.

Methane ($CH_4$) is mainly responsible for more than 25% of the warming *"[…] is a powerful greenhouse gas, with a global warming potential more than 80 times greater than that of carbon dioxide (CO2) during the 20 years after its release into the atmosphere"* (UN, 2023).

The sources of GHG emissions are of two types: a) direct GHG emissions (enteric fermentation, consumption of fossil fuels, use of synthetic fertilizers, burning of agricultural waste, handling of manure and consumption of refrigerants); and b) indirect GHG emissions (electrical energy consumption). By considering these GHG emission sources, the Carbon Footprint can be calculated and the corresponding decisions made (Páez-Barón, E. M; et. al, 2018).

There are various methodologies to calculate the carbon footprint, such as the proposal presented on the digital platform CONtextoganadero (2019), referring to the use of SG Livestock Software; or those proposed by the International Standard Organization, responsible for the development of the UNE-EN ISO methodology (Ihobe. Sociedad Pública de Gestión Ambiental, 2013); However, it is highlighted that; According to article 15 of LGCC, the INECC's purpose, among others, is to *"[…] promote and disseminate criteria, methodologies and technologies for the conservation and sustainable use of natural resources […]"*, which determine the National Inventory of GHG Emissions (LGCC, 2018).

Regarding the Water Footprint, the FAO estimated that just over 70% of global water use corresponds to agricultural activities; while the use of water by livestock is at a high level and constantly growing, from food production to product supply (Steinfeld, H., 2009).

The FAO considered that the drinking water needs (as a reference data) for livestock were the following: cattle from 103 to 126 liters/day/animal; pigs from 17 to 47 liters/day/animal; birds from 13 to 50 liters/day/animal; goats from 8 to 12 liters/day/animal; sheep from 9 to 20 liters/day/animal (Steiner, H., 2009).

**Impacts of climate change on livestock farming**

According to Juan Carlos Ayala (2023), General Director of the Agricultural Market Consulting Group (GCMA), a consequence of climate change is drought that has a direct impact on livestock production, by reducing the supply of food and water, causing the

death of livestock. and consequently, the reduction of the livestock population. As of October 15, 2023, more than 80% of the national territory was affected by some level of drought, with 51% of the country being in the severe to exceptional categories, these being the highest. An approximate number of livestock deaths due to drought is not recorded; However, it is estimated that 50% of the herd is in these conditions (Ganadería.com, 2023).

In livestock farming, the initial impact of drought is perceived in the reduction of available forage and, subsequently, in the decrease in production, which is reflected in the weight of the livestock and their reproduction rates (López, M.; et al. al., 2009).

The previous problem has a direct impact on food security: the supply of foods of animal origin (high-quality biological protein) decreases, its market price increases and causes greater difficulty in accessing nutritious and healthy foods, one of the six indicators[9] in the poverty measurement methodology used by the National Council for the Evaluation of Social Development Policy, CONEVAL (2021); Furthermore, the population's right to food enshrined in Article 4 of the Constitution is directly violated[10].

High temperatures affect the nutrition, fertility and well-being of livestock, caused by heat stress, which increases the animal's heart rate, body temperature and respiration.

Likewise, climate change affects biodiversity, animal health and productivity, as well as the availability and quality of forage and crops for animal feed (Deschamps, L., 2018).

**Some mitigation actions**

There are various alternatives and actions to achieve sustainable livestock farming in the medium and long terms: strategic feeding (nutrition), efficient management of animal genetics and reproduction, adjustment of the animal load in rangelands (avoiding overgrazing).

Consider in food efficiency, adjustments to protein levels and formulation based on amino acids, as well as the use of additives (Escribano, A. J., 2023).

An effective method has been what is called the Silvopastoral Livestock System, which consists of growing *"[…] legumes in the pastures, both herbaceous, shrubs and trees; of native plants to feed livestock, conserve forage, use live fences, use biological inputs (biofertilizers and biopesticides); and raise rustic breeds under difficult edaphoclimatic conditions."* (CDRSSA, 2020). *"[…] trees remove CO2 from the atmosphere and store it as cellulose, lignin and other compounds"* (United States Environmental Protection Agency EPA, 2023).

Increase in livestock productivity, *"There is a direct link between the intensities of GHG emissions and the efficiency with which producers use natural resources, that is, the amount of natural resources used in animal production, per unit of production edible or inedible. For livestock production systems, emissions of nitrous oxide, methane and carbon dioxide are losses of nitrogen, energy and organic matter that undermine efficiency and productivity. Therefore, potential interventions to reduce emissions largely rely on technologies and practices that improve production efficiency at the animal and herd level"* (FAO, s/a).

With the reform of the LGCC in 2018, the Federal Government established *"emissions trading*" to reduce GHG emissions; Carbon credits were created as financial instruments to support *"[…] the reduction of carbon dioxide achieved by some environmental, conservation or reforestation project of forests and jungles, and is equivalent to one ton of carbon absorbed from the atmosphere. Before purchasing bonds, a company must maximize cuts in its greenhouse gas emissions"* (García de León, V, 2022).

*"La Plataforma Mexicana del Carbono (MEXICO2) promueve la compra voluntaria de carbono y puede ser una opción para ranchos ganaderos en México […]"* (Jurado, P.; et. al. 2022). Apoya proyectos y acciones para proteger y aumentar el capital natural y social del país, según el IECC (2013).

[9] CONEVAL uses multidimensional methodology to identify the population in conditions of poverty; The indicators are the following: a) educational lag; b) lack of access to health services; c) lack of access to social security; d) lack of housing quality and spaces; e) lack of access to basic services in housing; f) lack of access to nutritious and quality food.

[10] Article 4. Constitutional: "Every person has the right to nutritious, sufficient and quality food. The State will guarantee it." Paragraph added DOF 10-13-2011.

*"The Mexican Carbon Platform (MEXICO2) promotes the voluntary purchase of carbon and can be an option for livestock ranches in Mexico […]"* (Jurado, P.; et. al. 2022). Supports projects and actions to protect and increase the country's natural and social capital, according to the IECC (2013).

**Conclusions**

Mexican livestock farming is part of the entities that collaborate with global warming, at the same time suffering the negative impacts of this global problem. Recurrent droughts, extreme temperatures, and the presence of higher intensity hurricanes have caused deaths of livestock, problems in nutrition, reproduction, and animal well-being (such as heat stress); decreasing productivity, which could generate in the medium and long term a shortage of foods of animal origin and therefore an increase in exports in this matter, which would cause a deficit trade balance and economic consequences for the country.

Highlight the actions that should be promoted in livestock farming, proposed by the Mexican Carbon Platform, such as the universal development of methane capture projects in production units, particularly in cattle and pigs; use of digesters for the capture and burning of biogas that prevents its release into the atmosphere, landfills and reforestation, among others, such as the development of silvopastoral systems, the balance of nutrients in ruminants, mainly and the obtaining of offspring, from of genetic parameters of greater resistance to extremes and climate changes, to achieve greater resilience.

And with this, continue to preserve livestock farming as a dynamic economic activity, with a surplus in the trade balance that, until August 2023, was more than 600 million dollars, only in exports of live cattle and honey. bee (SIAP, 2023); Likewise, it represented 40% of the agri-food GDP and 8.2% of the national economy (Ganadería.com, 2023).

It is estimated that by 2050 the world population will be just over 9 billion people, causing the use of greater natural resources (land and water). That, in the words of González, P. (2020), foods of animal origin will increase their consumption, for example, meat by 73% and milk by 58%, compared to 2010. *"[…] The above, poses the challenge of maintaining a balance between productivity, food security and the preservation of the environment"* (González, P. 2020).

Foreign Minister Rodolfo Nin Novoa (Uruguayan) said at the 12th meeting of the Conference of the Parties to the Ramsar Convention on Wetlands (COP 12), held in Punta del Este, Uruguay in June 2015 ***"Nature can live without man, but man cannot live without nature".***

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