



# Livestock Production in Front of Population Growth and Climate Change Challenges: A Threaten to Extensive Farming Systems or A Balanced Coexistence with Intensive Systems?

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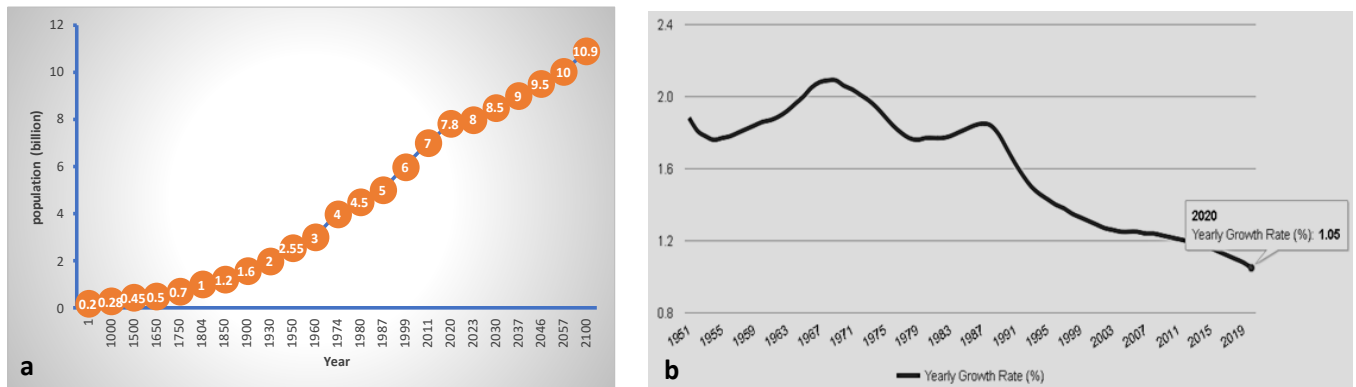
## Abstract

*The present report focuses on highlighting the response of livestock production towards the double challenge of population growth and climate change. Intensive and extensive systems are taken into account as the major contributors for overcoming these challenges. Their future participation in the coverage of the increased demands of animal products trying, simultaneously, to retain a green footprint by terms of a decline environmental impact is discussed. Both types of livestock systems could contribute with a positive impact on the aforementioned challenges, but extensive systems, although their key advantages for animal production, seem to need further adaptation in order to overcome these challenges.*

**Keywords:** Animal Production, Climate Change, Husbandry, Livestock Systems

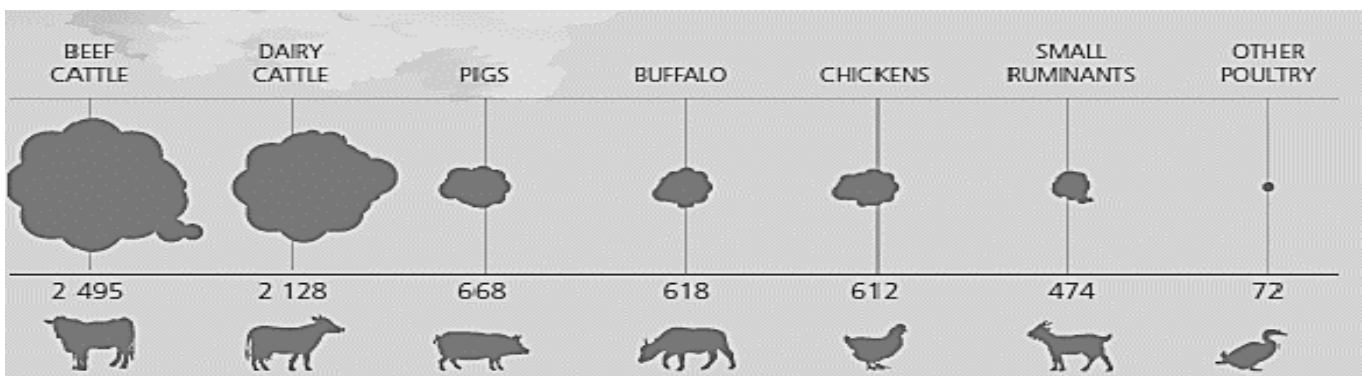
## Introduction

World's population reaches almost 7.8 billion of human beings with a growing rate of around 1.05% per year, which means an average population increase of 81 million people per year. Despite the recent (2020) observed slower population growth per year (1.05%, Fig. 1) compared to that observed at previous years (down from 1.08% in 2019, 1.12% in 2017, 1.35% in 2000, 1.79% in 1980 or 2.07% in 1970), the global population is expected to reach about 8.6 billion of human beings in 2030 and 9.7 billion in 2050 (UN, 2019). As a result, the needs for animal products are estimated to be doubled up to 2050. In addition, together with urbanization and amelioration of the social status, livestock sector is forced to cover the increased food demands both by terms of quantity and quality in affluent as well as in less affluent countries.



**Figure 1:** Estimated world population (a) and population growth (b) (Source: [www.worldometers.info/world-population](http://www.worldometers.info/world-population))

Result of the aforementioned is that the sector tends to require more and more amounts of natural resources in order to cover the increased demands. On the other hand, animal production sector is led to an environmental “dead-end” as it is accused of being responsible for the 14.5% of the total anthropogenic green-house gas (GHG) emissions. By quantifying this, it means that over 9 million of CO<sub>2</sub> equivalents (eq.) are emitted every year due to livestock activity. GHG emissions from livestock sector account for CO<sub>2</sub>, CH<sub>4</sub> and NO<sub>2</sub>. The major sources for these emissions are considered the enteric fermentation, the feed production and processing, the manure as well as transportation and further processing of animal products (Gerber *et al.*, 2013; Rojas-Downing *et al.*, 2017). Ruminant sector, especially beef cattle followed by dairy cattle and buffaloes are considered the main contributors of GHG emissions, participating in the “tank” of global warming potential with over 74% of the total CO<sub>2</sub>eq of livestock GHG emissions (Fig. 2). Small ruminants as well as pig and poultry sector contribute lesser to livestock's environmental footprint (FAO, 2017). How the sector will cover the increased demands in animal products with the minimal environmental impact of the implemented farming system is a major question that may arise from the above described data but also multifactorial driven.



**Figure 2:** Contribution of livestock species (per animal species) to global greenhouse gas emissions (emission intensities are expressed in Mtn CO<sub>2</sub> eq.; adapted from [www.fao.org/climate-change](http://www.fao.org/climate-change))

## Animal Farming Systems, Environmental Impact and Increased Food Demands

The elimination of livestock systems adopting the “vegan” diet as a holistic nutrient intake approach it could form an alternative for diminishing livestock's carbon footprint, due to its lower environmental impact (Chai *et al.*, 2019). However, it generally receives plenty of criticism on whether it can fully cover the human nutritional needs, as many of the so-called necessary nutrients can only derived from animal products. Besides, it is not certain if adopting such an approach there would be a reduction in the environmental footprint as more crop cultivated areas would be needed to meet increased human food demands meaning, thus, a higher potential environmental impact. In addition, the elimination of animal farming systems as a result of the implementation of such approach will lead to profound impacts on various environmental and economic aspects. Livestock production forms a vital economic pylon in many countries both by terms of farmers income and gross domestic product index. The sector, also, assists to avoid soil erosion, because cultivated areas are used as a source of animal feed production. Besides, the absence of livestock systems simultaneously means important biodiversity loss and disruption of ecosystems.

Another approach could easily argue that to meet the increased demands for animal products in the forthcoming years, an increase implementation of intensive systems could contribute positively. However, this might end up in an increase of livestock's environmental impact. Intensive systems can do cover the increased demands by term of quantities and also by terms of quality under certain circumstances (i.e. feed supplementation, selection for certain traits etc.). The higher environmental impact can be restricted, as the sector nowadays is not aware of mitigation practices. Such approaches may include changes in feeding practices, manure management and utilization as well as proper animal management (Grossi *et al.*, 2019). A 1% increase of dietary fat can decrease enteric methane emissions between 4-5% (Martin *et al.*, 2010). Feed antibiotics can, also, reduce enteric fermentation (Boadi *et al.*, 2004), while improving diet digestibility by increasing concentrate feeding seems to reduce methane emissions per unit of fat protein corrected milk (Knapp *et al.*, 2014). Frequent removal of manure to an outside storage facility could reduce methane and nitrous oxide emissions over 40% (Mohankurmar Sajeew *et al.*, 2018), or solid-liquid separation process of manure could lead to 30% lesser emissions compared with untreated manure (Montes *et al.*, 2013). Improving the fertility in dairy cattle could lead to a reduction in methane emissions by 10–24% and reduce nitrous oxide emissions by 9–17% (Loonch *et al.*, 2017).

In the same line, the on-going improvements on more accurate genomic selection approaches (i.e. SNPs chips) and progress on animal selection strategies at the level of productive traits as well as at the level of physiological indexes (i.e. better feed efficiency) or animal health (i.e. resistance to pathogens, well-being, etc.) are and will be further beneficial for improving a livestock's efficient and increasing their productivity. Breeding for more productive animals usually diminish the nutrient requirements assisting to lower GHG emissions (Grossi *et al.*, 2019). Diseases influence negatively the environmental impact of a livestock. For instance, cattle diseases can increase GHG emissions up to 24% per unit of produced milk and up to 113% per unit of produced beef carcass (Williams *et al.*, 2015). In addition, intensive systems will be probably a solution to developing countries, where the vast majority of population will be located in 2050. Apart from covering local needs, these systems would be also beneficial for eliminating massive imports of animal products from abroad countries as well as for employability and retailing distribution increase.

On the other hand, the vast expansion of intensive systems could lead to an inadvertent reduction of extensive systems with the etiology of being less efficient. The approach of eliminating such systems would not be an optimal solution as they contribute to various socioeconomics aspects. Extensive systems usually focus on breeding specific local breeds, many of them already characterized as rare. They, also represent a reservoir of animal biodiversity as a result of natural and zootechnical selection implemented over the past years. In a similar fashion, they constitute an “alive” genetic pool, which could serve as a vehicle for overcoming future challenges (i.e. hazard breeding conditions). Simultaneously, these breeds reveal resistance to harsh environments, ability to exploit the poor arid land pasture, disease resistance, survivability under restrict amount of foods and water as well as they can provide final products with unique qualitative characteristics. The aforementioned key advantages combined with a balanced breeding scheme could provide an important added value to the final product. Moreover, these characteristics could be proved vital for the adaptation of intensive systems towards climate change. Therefore, instead of eliminating the extensive farming systems a more effective approach is required to be adapted. The improvement of their sustainability combined with a greener footprint label in the final output (i.e. milk, meat, egg etc.) would be a first option. Technical practices should be further studied as key to the vital preservation of extensive farming systems. The already techniques-mitigation strategies used in intensive systems may not be so sufficient to improve their

efficiency and further economic sustainability due to differences existed between the two types of livestock systems. Animal breed should also incorporate the maximum available genetic information in order to speed up response towards the impacts of climate change because these systems are more vulnerable to extreme climate conditions. Despite the major improvements on molecular level, linking the genetic information retrieved from local breeds with a certain phenotype resistant to climate change, which may also assist to a lower environmental impact is still a missing puzzle. In addition, linking these systems with products that emerge particular qualitative characteristics targeting specific consumers' needs (i.e. rich in  $\omega_3$ :  $\omega_6$  lipid acids), could offer added value to the final product and thus, higher recognizability of these systems. Besides, it should not be omitted that extensive livestock systems not only enhance the social cohesion as they offer income to thousands of families living in (semi-) mountainous areas (Davies *et al.*, 2010), but also in many countries are used for improving the wildfire prevention strategies as well as they are linked with various customs developed over the past years.

### **Extensive or Intensive Systems Towards to a Greener Footprint?**

Another important factor that should be considered is that extensive systems have been assigned with higher environmental impact by terms of Kg/ produced product compared to intensive systems, mainly due to the more inputs needed to produce the same amount of edible product (e.g. meat or milk) compared to intensive systems resulting, therefore, in higher GHG emissions for a given quantity of product (Garnet, 2010). Also, the impact depends on the specie used (i.e. local or commercial breeds), the boundaries of the system used for emissions' estimation and the type of farming systems (i.e. organic, free range etc.).

Batala *et al.* (2015) reported that more intensive farms producing ovine milk using commercial breeds had a lower carbon footprint than semi-intensive farms using commercial or local breeds, respectively. However, when soil sequestration was included in calculations, no differences between the farming systems were observed in regard to GHG emissions. Another research focused on the footprint of small-scale cattle dairy farms in mountainous areas (Salvador *et al.*, 2016). Conventional and organic farms were compared, using a local Italian cattle breed. Emissions' estimation were conducted up to the level of farming gate, without incorporating the impact of further processing or transportation. Results showed that enteric fermentation and eutrophication levels were higher in organic farms compared to conventional taking into account the production of 1 lt of bovine milk. However, when beef was considered as co-product emissions were rather similar.

A characteristic example of improving environmental footprint is the broiler production (meat chicken production) in the United States (Putman *et al.*, 2017). Producing the same amount of meat chicken nowadays as in the middle of previous century has 50% less environmental impact. This is a result of fewer resources engaged in the production systems, the decrease in the area and the water used and on the other hand the increase in using alternative energy sources by farmers. In addition, according to a Nielsen *et al.* (2011) the production of 1 Kg of broiler contributes to the global warming potential with 3.85 Kg of CO<sub>2</sub> equivalents. Hatch egg production followed by slaughterhouse level had the lower emissions (0.52 and 0.39 Kg CO<sub>2</sub> eq, respectively) compared to broiler production stage (2.94 Kg CO<sub>2</sub> eq). Similar levels have been also reported by other studies (LCA Food, 2006; Katajajuuri, 2007) but results are not so easily comparable due to different methods, functional units or boundaries used during farming system's environmental impact assessment.

Regarding egg production, free range systems revealed to have a higher environmental impact compared to organic system, barn system or the even cage system used in the past, in regard to global potential warming, eutrophication or acidification impact (Leinonen *et al.*, 2012). According to Nielsen *et al.* (2013), 1.8 Kg CO<sub>2</sub>- eq are emitted per 1 Kg of produced eggs. Williams *et al.* (2009) compared organic production systems, free range systems and conventional farming systems of meat broiler or egg production. In both examined categories, free range systems had higher carbon footprint compared to free range or conventional systems.

A recent research (Senga Kiese *et al.*, 2020) examined the environmental footprint of dairy cattle farms in regard to extreme differences in forage intake by terms of minimum or maximum dry matter intake from grass or maize. Farms with high DM intake from grass had 13% lower gross carbon emissions potential that farms with low DM intake. On the other hand, farms with high DM intake from maize had 25% higher CO<sub>2</sub> emissions. When the functional unit (unit of expressed results) was the 1lt of produced milk (thus taking into account the emission intensity and not gross emissions), an opposite trend was noted. Farms with high DM intake from grass had 17% higher global warming potential that farms with low DM intake. On the other hand, farms with high DM intake

from maize had 1% lower warming potential in terms of CO<sub>2</sub> eq. Therefore, environmental impact of livestock systems is a multi-factorial matter. It is influenced mainly by the system boundaries used for the emissions' estimation and the type and orientation of the system.

## Conclusion

Considering all the aforementioned, the “gravity” of the environmental impact of extensive or intensive systems depends on the studied livestock's boundaries, the used of functional unit and the implemented farming practices. Up to date, extensive systems appear to have a higher environmental foot print compared to the intensive ones. However, both systems emerge advantages for mitigating both climate change impacts and future increased demands for livestock products due to population growth. Besides, extensive systems need a further adaptation approach to these challenges, mainly due to their lower productivity. Both systems should coexist and “feed” each other in order to achieve the greatest possible effect both on the challenges posed by climate change and population growth so as to meet future nutritional needs of human beings.

## Conflict of Interests

There is no conflict of interest.

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