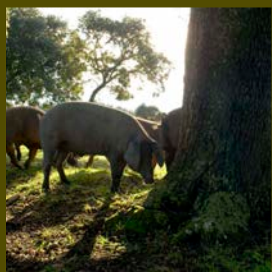
ENTRETANTOS NOTEBOOKS 6

EXTENSIVE FARMING AND CLIMATE CHANGE
AN IN-DEPTH APPROACH



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PLATAFORMA POR LA
GANADERÍA EXTENSIVA
Y EL PASTORALISMO

This report, co-edited by the Fundación Entretantos and the Plataforma por la Ganadería Extensiva y el Pastoralismo (Platform for Extensive Livestock Farming and Pastoralism) brings together and organizes the intensive collective work carried out by the Platform to address the adaptation to and fight against climate change from the perspective of extensive livestock farming.

The process started with a series of debates within the Platform on the role that extensive farming plays in the climatic scenario, its emissions, adaptation needs, and mitigation potential. Over time, these debates integrated experiences, scientific papers (some signed by the people who were part of the debate), innovative practices (arising from the reality of active farmers), and political proposals that share one global idea: The need to radically change, both on a technical as well as on a scientific and political level, the current understanding of the relation between climate change and extensive livestock farming.

The richness of the debate and the ideas proposed encouraged us to present them in the past COP25 meeting in Madrid. The presentation was organized collectively, in a round table that brought together simultaneously people connected to the scientific world, researchers, activists and, of course, farmers. The picture taken during the event reflects very clearly the working style and collective spirit that best define the Platform's identity.

The next step was to transmit these ideas to the rest of the society with the purpose of spreading the adoption of this shift in perspective, especially among people and organizations working in the fields of livestock, agriculture and food. This is how the initiative of editing and distributing this report came up.

The report organizes new and old ideas, all supported by a solid scientific foundation. This is indeed a technical document. However, the idea was to make it understandable and accessible to anyone interested by separating the main ideas from a series of additional materials.

So, even if the main text is informational and accessible, the report includes numerous boxes describing and referring to scientific papers, reports, and technical documents in Spanish and English, which help substantiate contents and found opinions. To sum up, the aim is to raise awareness on the huge potential of extensive farming to make food production more sustainable and secure in the current context of climate change, and on its irreplaceable role to reduce and adapt to the effects of climate and global change.

From left to right: Concha Salguero (Asociación Trashumancia y Naturaleza), Marta Rivera (researcher, member of the IPCC and the Agroecology Chair of the University of Vic), Gerardo Moreno (researcher, University of Extremadura and INDEHESA), Elisa Oteros (Researcher and member of FRACTAL), Pablo Manzano (researcher and international consultant on pastoralism), Joan Alibés (farmer, business owner and member of the Sociedade Galega de Pastos e Forraxes), Monte Orodea (farmer, member of Somos Sierra Norte and Ganaderas en Red), Pía Sánchez (famer, member of GER and President of FEDEHESA), and Pedro M. Herrera (Fundación Entretantos).

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Many other members of the platform made contributions and quotes, and fueled the debates. Some of their names appear, others do not. But everyone's contribution was essential to the end result.

COP25 round table coordination: Elisa Oteros, with support from María Turiño and Ganaderas en Red.

Pictures: Marta Ibáñez, Víctor Casas, and Javier García

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PLATAFORMA POR LA GANADERÍA EXTENSIVA Y EL PASTORALISMO

Life Live Adapt

Life

CONTENTS

OVERVIEW

Livestock farming and animal production in general are highly relevant to climate change, as the great media attention paid lately to the subject shows, and confusion and animosity in connection to livestock farming are on the rise. Productive farming of domestic animals is, on the one hand, a source of greenhouse gases (GHG), but also a vulnerable sector to climate change that is necessary for the conservation of grazing ecosystems and for our diets.

Climate impacts have turned out especially intense in agricultural activities. In the case of livestock farming, climate change is also highly relevant to the wellbeing and health of the animals raised. Also, it is a key sector for food security and the production of food on a global scale. The livelihood, savings, and risk management mechanisms of millions of people depend on it, as well as countless ecosystem services and many small-scale economies.

Livestock farming, in general, contributes to the emission of greenhouse gases through the emissions of domestic animals, the consumption of energy and inputs, and the management of manure and slurry. These emissions include carbon dioxide as well as methane and nitrogen, especially in the form of nitrous oxide. But not all livestock farming systems are the same nor emit greenhouse gases similarly. Even if there are great differences between them, we can divide them into two large blocks: extensive farming and intensive or industrial farming, with many in-between systems.

Extensive farming uses local forage resources through grazing, usually keeping breeds and varieties adapted to the conditions of the environment and with low demand of external inputs, both material (feeds and other foods) and energetic, thus thriving in sustainable conditions. These traits set extensive farming clearly apart from industrial production, which happens in confined facilities, using feeds that come from conventional markets—often from other countries—generating polluting waste, and demanding high levels of energy and other external inputs.

This report intends to address the role that extensive farming can play in the context of climate change, both in connection with improving the assessment of its emissions and their derived effects, as well as contributing to its adaptation, and above all, harnessing all its potential to fight climate change.

This document is structured into 7 sections addressing different aspects of the link between extensive farming and climate change, including the different models of livestock production, emissions, the territorial context, how grazing integrates in the ecosystems, the effects of climate change, and adaptation and mitigation proposals. A final chapter draws a series of conclusions and proposals for the future.

This report is conceived as a technical guide to raise awareness on the main arguments that connect extensive farming to climate change, while providing access to abundant sources and reports. To this end, highlighted boxes appear interspersed in the text, referring to relevant technical or scientific publications related to the aspects addressed in each section.

A MORE PRECISE CONTEXT TO UNDERSTAND THE CONTRIBUTION OF EXTENSIVE LIVESTOCK FARMING TO CLIMATE CHANGE

Up to now, the consideration of livestock farming in the context of climate change was linked, in most cases, to the global behavior of agriculture. By contrast, the specific work analyzing the role of livestock farming in connection with climate change is characterized by a somewhat blurry assessment that does not differentiate intensive from extensive production.

Despite this, the discussion on the global effect of livestock farming on climate change has been a recurring theme in the last months, both in the media as well as in scientific environments and in the public debate, feeding the growing call to base human nutrition on a vegan diet.

In these cases, livestock farming is usually considered as an undifferentiated block, without distinguishing productive systems or adequately considering the wide set of connected activities.

This approach neglects key aspects to analyze the effects of livestock farming on the agro-ecosystems that sustain it and on climate change, like feeding methods, associated feed and forage production, energy consumption, transportation of forage, live animals, and slaughtered animals, and other external inputs (from additives to drugs, antibiotics or supplements).

The IPCC Special Report on Climate Change and Land is the first comprehensive scientific assessment of the links between land and climate change.

The job follows a massive effort that involved dozens of scientists to assess the interactions between climate change, desertification, soil degradation, sustainable land management, food security, and the fluxes of greenhouse gases on terrestrial ecosystems.

Therefore, this analysis is closely connected to farming, and offers some important keys that connect agricultural activity to the major.

Most scientific reports and works on the connection between livestock farming and climate change ignored the existence of different livestock farming systems, with dissimilar operating methods, emission profiles, and socio-ecological characteristics.

This lack of differentiation is leading to painting with the same brush activities that are essentially different, both in terms of concept and implementation as well as, of course, in their climatic and environmental performance.

The main consequence of this situation is that the whole livestock farming sector is identified with the more industrialized farming. On the one hand, this has strongly skewed the analysis by equating the behavior of all the sector with that of one single productive system, and on the other hand, it has prevented a correct understanding of the diversity of livestock farming systems, which is detrimental to climate change adaptation and mitigation options.

Ultimately, this situation is also having a clear social impact. Increasingly negative news about livestock farming are being aired, influencing large numbers of people who adopt vegan diets and antispecist positions, and reject all animal source products, deeming that all livestock is detrimental to the planet.

FAO published in 2013 the report '[Tackling Global Change Through Livestock – A Global Assessment of Emissions and Mitigation Opportunities]', written by a group of authors led by J. Gerber.

This report, as well as the GLEAM model (Global Livestock Environmental Accounting Model) also developed by FAO, and other previous papers, consider livestock farming and its emissions as a whole, without setting extensive farming apart from intensive, or industrial farming.

For a global understanding of the situation of livestock farming in connection with the effects of climate change, and vice versa, this scientific paper may also be referred to: '[Climate Change and Livestock: Impacts, Adaptation, and Mitigation]', signed by Melissa Rojas-Downing and other contributors to the magazine Climate Risk Management.

Luckily, things are changing in the last years, and many journals have started to distinguish the different animal production systems, trying to develop specific analysis and proposals for each of them. Along the same lines, proposed analysis and control system-specific indicators are starting to be adopted, enabling the individual analysis of each productive system's contribution to climate change, and its specific adaptation and mitigation measures.

Because of their relevance and dramatically different traits, extensive systems stand out from the rest. In turn, they encompass greatly diverse approaches, ranging from mobile grazing to silvopastoral systems that use complex grazing landscapes of pastures, crops, and woody vegetation, or those relying on common lands found several regions of the world.

It is increasingly clear that the different livestock farming systems provide the societies that host them diverse goods and services, thus requiring distinct approaches that cannot be managed using one single set of criteria.

There is an additional reason: each system may implement different strategies to tackle climate change adaptation and mitigation, something very hard to do if the previous analysis were not adequately separated and addressed from specific perspectives, or if measures interfere with each other.

Moreover, the differentiated analysis and assessment of these systems must stress their global behavior in terms of the environment and sustainability, as well as the different roles they play, both in terms of the functioning of the ecosystems, as well as in connection with diverse social and economic factors.

Obviously, highly concentrated and industrialized animal factories, clearly turned into macroeconomic stakeholders in the most developed countries, do not play the same role than the systems in African domestic economies, where grazed herds and animals act as savings deposits, a risk management strategy, a source of staple food for families, a source of income in times without harvest, etc.

On another level, in Spain and the rest of Europe, there are still many extensive farming systems that play an important role, both in the agricultural economy, as well as in land management and the sustainability of rural areas in general.

Due to their relevance, we must mention long and short transhumances , pastoralism, mountain stock farming of goats, sheep and cows, sheep-cereal systems, dehesas, and silvopastoral and agroforestry systems, as well as a great number of traditional livestock activities that struggle to survive.

TWO DIFFERENT MODELS OF LIVESTOCK FARMING PRODUCTION

Based on former approach, productive livestock farming systems can be divided into two main models that should be analyzed and addressed separately, and be fully disaggregated when it comes to designing public policies, regulations and strategies.

They are traditionally referred to as extensive livestock farming and industrial, or intensive, livestock farming. Table 1 shows some of the main differences between the two models, providing additional reasons for differentiating them.

Models	**Extensive farming (based on land unsuitable for food crops)**	**Intensive farming (based on land suitable for food crops)**
Food	Recursos locales de base territorial (pastos, dehesas, matorrales, bosques, barbechos, rastrojos...)	Alimentos preparados adquiridos en el mercado (piensos, cereales, etc.)
How food is accessed	Grazing	Provided by the people in charge of the facilities
Mobility	Animals can move freely within the space assigned to them	Restricted mobility
External inputs	Low level of external inputs	High level of external inputs (energy, feed, additives, drugs, machinery, etc.)
Energy and material flows	Flows are integrated into local economies	Flows are independent from local ecosystems
Housing	Outdoors, may be taken indoors based on weather conditions	Confined indoors, they live in facilities under controlled conditions (ventilation, heating, etc.)
Ecosystem services	They provide diverse ecosystem services: habitat maintenance, carbon sequestration, biodiversity conservation, etc.	No relevant ecosystem services provided
Environmental impact	Emission of greenhouse gases (CH_4 y N_2O)	Emission of greenhouse gases (CO_2 through deforestation, CH_4, N_2O), pollution trough fertilizers, pesticides and slurry, loss of biodiversity

Table 1. Main differences between the extensive and industrial livestock farming models. There are diverse in-between models, that we may refer to as semi-extensive, which are very relevant in several countries and regions. Mixed farms that combine grazing with indoors feeding, very common in mountain and cool climate areas in Europe, or sucker herds, that combine grazing with feedlots for animals that will be slaughtered.

Besides the aspects mentioned in the Table, additional arguments make a case for addressing both models separately, i.e. their different capacity to adapt to changes in external conditions, their resilience enabling them to recover after disruption or damage, their sustainability or their potential as a tool for land management, as well as their social implications. Extensive farming is an economic activity that cannot be offshored, and has great relevance in an increasingly global economy.

An example about the situation of the Spanish livestock production can be find in the report Huella ecológica, económica, social y sanitaria de la Ganadería en España (Ecological, Economic, Social, and Health Footprints of Livestock in Spain) published in 2018 by the Fundación Entretantos together with the cooperatives Garúa & Cyclos as the basis for a Greenpeace campaign, provides an analysis situation of livestock farming and its emissions in Spain.

As for sustainability, impact on climate change is an essential element that sets both modalities of farming apart. It works on one hand in terms of the GHS emissions generated by each model, and on the other hand on the capacity of the ecosystems that sustain them to fix atmospheric carbon and recycle other GHS.

Indeed, this behavior has generated a great wave of confusion due to the lack of differentiation when it comes to estimating the net balance of livestock farming GHG emissions. This generalization has favored serious errors of judgment that turned out very detrimental to extensive farming and pastoralist activities. The most evident of these errors is to consider the kilogram of meat (or milk) produced as the reference unit.

This specific metric benefits industrialized production models, since it offers biased results against extensive farming. There are alternative metrics that assess more adequately productions—like extensive farming—that generate public goods and ecosystem services, like pasture management, fire prevention, biodiversity conservation, or transferring fertility to the soil.

Numerous scientific reports signed by Spanish researchers expand awareness about the role of extensive farming in the provision of ecosystem services.

For example, Contribución de la ganadería extensiva al mantenimiento de las funciones de los ecosistemas forestales (Contribution of Extensive Farming to the Maintenance of Forest Ecosystems' Functions) presented at the VI Spanish Forest Congress by Pilar Fernández, Dolores Carbonero, and Alma García, or Alberto Bernués y Tamara Rodríguez's work published in the journal Plos/One entitled *Socio-Cultural and Economic Valuation of Ecosystem Services Provided by Mediterranean Mountain Agroecosystems*.

Also, in connection specifically with silvopastoral systems, we want to highlight a couple of papers signed by Gerardo Moreno, one was published by *Science Advances*, the other is part of a book on agroforestry systems edited by Rosa Mosquera at *Burleigh Dodss Science* (the latter is not publicly accessible, the original is available here).

The land base is also highly relevant in the environmental behavior of the farm. Globalized industrial flows, that supply industrial livestock farms, and in which these are integrated, involve many offshored impacts that must be accounted for carefully.

These include, among others, environmental, social, and economic impacts in the countries that produce cereals, soy, and other foods, the impacts generated by transportation throughout the productive chain, those imputable to the energy used by the facilities, etc.

Therefore, despite the fact that offshored impact caused by extensive farming have very serious social and environmental effects, it is very complicated to assess and act on them. On the contrary, the local presence of extensive farming implies that its impacts are much more evident, and therefore much easier to assign to the local productive system. This is another disadvantage with regards to industrial farming, as any impact generated affects the farm directly, rather than being socialized.

Lastly, efforts have focused essentially on quantifying greenhouse gases, without a parallel effort to quantify other negative impacts (i.e. loss of fertility, water use and eutrophication, nitrate pollution, etc.), and much less on quantifying environmental services (carbon sequestration, habitat conservation, fire prevention, etc.).

All this plays against extensive farming when analyzed comparatively with intensive farming, or even with the production of plant-based foods.

EXTENSIVE LIVESTOCK FARMING EMISSIONS

In the overview, the three main greenhouse gases associated with extensive farming were mentioned. Narrowing down the description, we can focus on the three main ones.

The first one is carbon dioxide (CO_2), the emissions of which are connected to land use changes, forage production, pasture management, the use of external inputs and, especially, energy and transportation, as well as other productive processes.

The second one is the nitrous oxide (N_2O) emerging from manure and slurry, and how these are managed, as well as from the use of fertilizers in forage crops.

The third one is methane (CH_4), emitted by ruminants' enteric fermentation, forage production connected to some types of crops, like rice fields, and by the stored manure and slurry generated by industrial livestock farming.

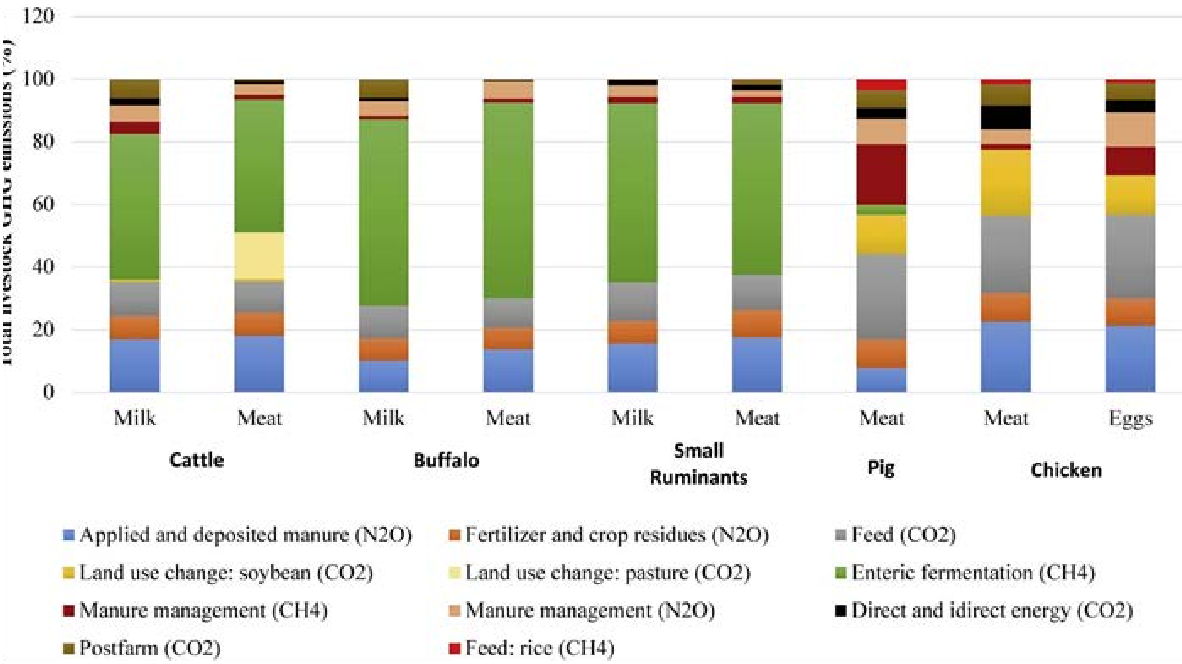


Figura 2: Different emissions per species and productive approaches. Adapted from De Rojas-Downing et al., 2017.

Greenhouse gas (GHG) emissions attributed to livestock farming have penalized extensive farming remarkably. The GLEAM model, the one most used to estimate these emissions, has serious flaws when it comes to considering the specificities of extensive and pastoralist production.

This simplification has produced inadequate estimations of the GHG emissions data connected to grazing, that appear overvalued and out of context. Calculations are based on general emission rates provided by the GLEAM method itself, that on many occasions are not adequate for most extensive farming models.

In 2020, Zhu and his colleagues estimated that nitrous oxide emissions from the excreta (urine and feces) of extensive cattle in Kenia's savannahs are up to 14 times lower than IPCC's estimated indexes. Also, numerous studies show that cattle methane emissions decrease up to 15-25% when their diet includes browsing woody plants, rich in tannins (see table in page 10).

But even using the general emission rates proposed by the GLEAM model, there are some aspects that need to be considered to qualify the position of extensive farming. If the set of emissions attributable to livestock (including CO_2 as well as CH_4 an N_2O) and their source are taken as reference, there is a set of emissions that clearly correspond to the realm of industrial models.

We are referring to emissions connected to land-use change (9.2%), slurry and manure management (21.6%, excluding the portion

connected to CH_4, that is 4.3%), and those connected to the management of fertilizers and crops for livestock feed production (7.7% of N_2O and 13% of CO_2), as shown in figure 2.

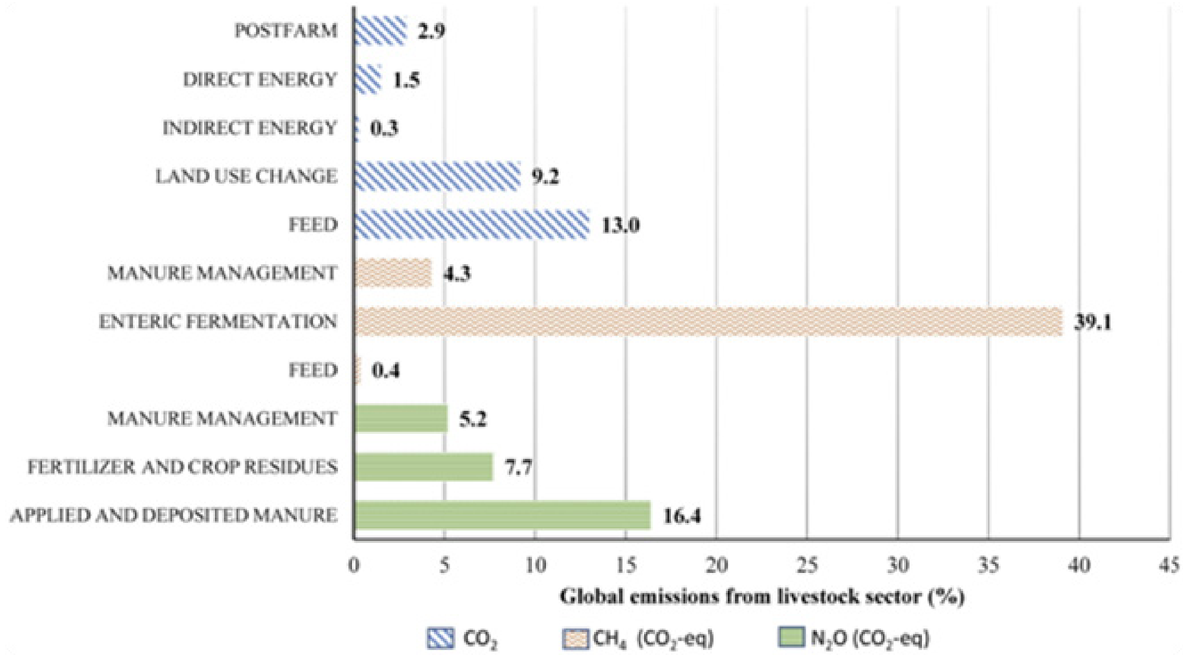


Figure 2. Global Emissions from the Livestock Sector (Rojas Downing et al. 2017)

Along those same lines, even without clearly distinguishing between productive systems, just by considering the species, we see a very different emissions profile. Ruminants involve mostly enteric emissions connected to their depositions (urine and feces), while the footprint of monogastric animals—especially chicken and pigs, highly industrialized—is directly connected to slurry management,

the agricultural industry of feed production, and changes in land use (Figure 1). These emissions need to be dealt with in a specific and differentiated manner, since in addition to their effects on climate change, they also have a great environmental impact where they happen.

There are other key aspects in the attribution of emissions to livestock that are clearly detrimental to extensive farming. Considering methane and carbon dioxide differently is one of them. Traditionally, methane's greenhouse effect is estimated to be between 23 and 35 times higher than that of carbon dioxide, but it is important to bear in mind that CO_2 remains much longer in the atmosphere, thus having a much higher accumulation capacity. To be precise, methane persists in the atmosphere for 12 years, while the persistence of CO_2 varies, but tends to be centuries, or even millennia (Figure 3).

Basic research is still needed, but some recent findings published by Kou and Tang and their respective colleagues in recent dates (see table in page 10) show that it is precisely pastoralist ecosystems where a significant portion of methane may oxidize

to CO_2. Therefore, we should in all cases preserve and optimize the pastures that feed extensive livestock and include the potential of agrosystems to reduce the atmospheric concentration of methane in their net emissions balance.

These statements are backed by scientific work that elaborates on the incidence of grazed livestock emissions. The papers mentioned in the text include the work by Zhu and colleagues published in the journal *Soil biology and biochemistry* in 2020, and the work signed by Aboagye and Beauchemin in the journal *Animals* in 2019.

The effect of grazing in methane emissions is referred to below in this text. For more information on this, please consult Tang and colleagues 2018 paper published in *BMC-Ecol*, or Kou and colleagues paper published in the above-mentioned *Soil biology and biochemistry* in 2017.

On the effect that grazing has on the emissions from ecosystems, discussed in the section below, please refer to Medina-Roldán's paper published in 2019 in the journal *Agriculture, Ecosystems & the Environment*.

Elaborating on the chemical reactions that take place in agrosystems, nitrous oxide emitted from livestock urine and feces

also sets extensive farming models clearly apart from industrial farming. In intensive models, animal's urine and feces are mixed producing ammonia that later oxidizes to forms of nitrogen oxides, which have great global warming capacity. On the contrary, this phenomenon barely happens, or it happens to a much lesser extent, in extensive systems where liquid and solid fractions are not mixed.

Also, they integrate rapidly with the soil, thus becoming quickly available to plants and microorganisms and avoiding emissions to the atmosphere.

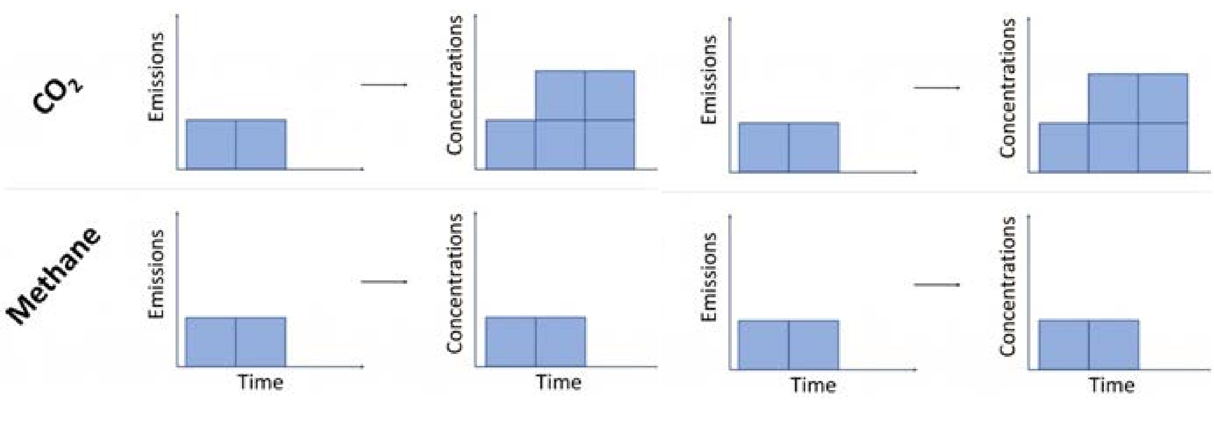


Figure 3: Methane and CO2 persistence and concentration in the atmosphere. While methane breaks down some time after being emitted, CO2 accumulates for centuries. Adapted from Allen, M.R. et al. (2017).

In addition to the shortcomings in the process of estimating extensive farming emissions, the fact that most reports ignore the system's capacity to sequester atmospheric CO2 and store it as soil biomass or organic matter is also detrimental to this farming model. That is, it is not just animal emissions that should be accounted for, but also the carbon sequestered by pastures and stored in the soils, as well as the methane oxidized. This would be a net emissions model much closer to the complex reality of these productive systems (Figure 4).

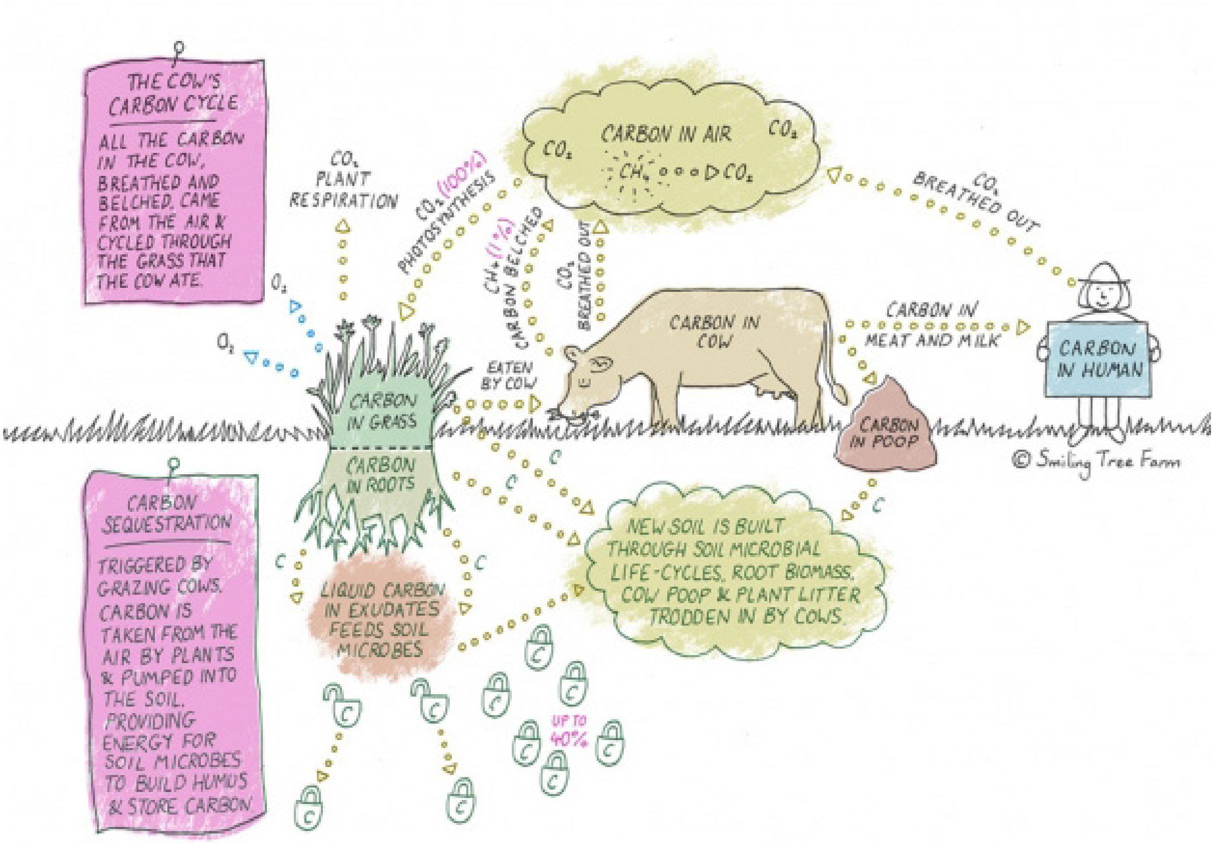


Figure 4. The complex movement of carbon in the soil-animal system. From https://www.smilingtreefarm.com/blog/carbon-mooooves

A post on the blog of the Red Remedia by Gerardo Moreno and Mireia Llorente shows how soils behave in the dehesa ecosystem in terms of carbon sequestration, which far outweighs the emissions of animals that graze there. Overall, well managed pastures have great capacity to sequester and store carbon in a stable manner.

However, probably the largest simplification in the current emissions calculation models—that once again plays against extensive farming—is the emissions metric itself, based exclusively on the emissions of CO2 equivalent per kilogram of final commercial product. Conversely, if the different goods and services produced by extensive farming were accounted for, obviously including the public ecosystem services generated, the situation would be much more favorable to grazing-based models.

One last remark about emission calculations and, in general, the climatic behavior of extensive systems, is the lack of research based on real data.

There are major knowledge gaps in key aspects of the biogeochemical dynamics of certain productive systems (like soil-animal extensive systems) and geographical areas with very specific characteristics, like the Mediterranean region.

It is particularly important to intensify basic research efforts on emission types and flows, especially on how they relate to productive systems and land management.

The graph shows the imbalance between scientific research on one specific topic and the importance of emissions attributed to such topic in the Inventario Nacional de Emisiones (Spanish National Inventory of Emissions).

A specially revealing fact is how little research there is on key livestock management aspects (like enteric methane or manure management), considering that very significant emissions are attributed to them.

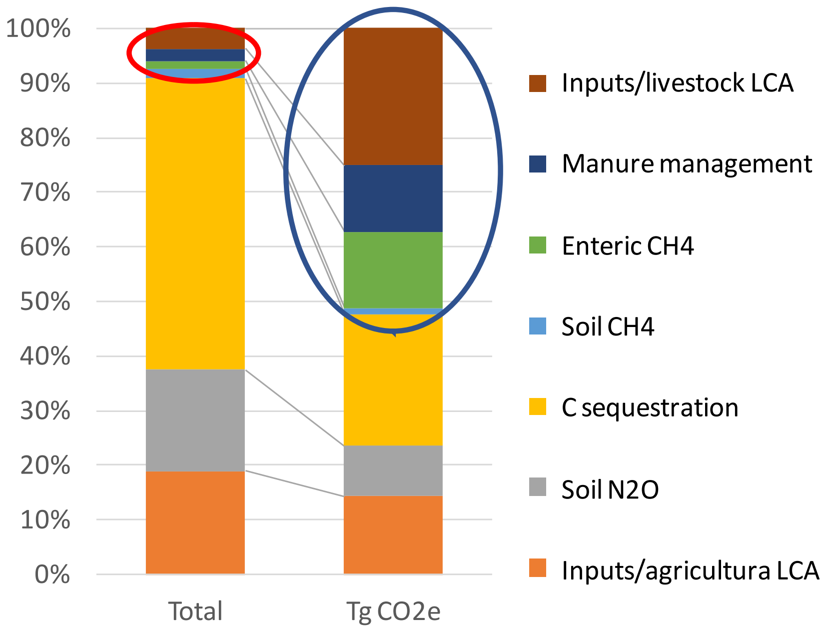


Figure 5: Connection between the number of scientific publications referred to the different topics related to agriculture, livestock, and climate change, and the importance of the emissions attributed to such topics in the Spanish Inventario Nacional de Emisiones. Data from the research Producción Ecológica Mediterránea y Cambio Climático: Estado del Conocimiento (Aguilera et al., 2018).

The report Producción Ecológica Mediterránea y Cambio Climático: Estado del Conocimiento (Organic Mediterranean Production and Climate Change: State of Knowledge) published in 2018 by the Cátedra de Ganadería Ecológica Ecovalia-Clemente Mata shows the lack of research on GHG emissions from extensive farming, which is highly detrimental to the sector in terms of the calculations and inventories carried out by the authorities.

THE LAND-BASED APPROACH

EThe high level of integration between pastoral systems and local ecosystem processes raises an additional key issue for analyzing extensive farming behavior in connection with climate change: the level of emissions from these ecosystems (or territories) if extensive livestock were eliminated or stopped grazing the land.

Throughout a year, a terrestrial ecosystem like a pasture generates a primary production of plant material through the photosynthesis of the plants that use free-air CO_2. Temperature, humidity, fertility, and soil biological activity, among other conditions, determine the amount of biomass produced in each moment. This new plant material integrates in plant roots, stems, and leaves as cellulose, starch, and other carbohydrates, fat proteins, etc.

A portion of this biomass provides the energy basis for the rest of the ecosystem, consumers, and decomposers, who degrade a fraction to obtain energy, returning to the atmosphere most of the carbon that had been previously captured by plants.

However, a small but significant portion is accumulated in the soil biomass and organic matter, where it remains for a longer or shorter period, depending on its nature. Leaves, pastures, and fine roots are recycled in virtually annual cycles, and lignified structures in cycles that range from several years to centuries in the case of the oldest trees. Likewise, the soil contains labile organic matter that is oxidized (breathed) by the soil microbiota in a few years, other portion is stabilized and may remain in the soil for hundreds or thousands of years.

The balance between the biomass produced (CO_2 fixation) and the biomass degraded by the ecosystem (CO_2 emission), allows us to know whether the ecosystem is fixing carbon (generating more biomass than it breathes, thus accumulating a portion of it), if there is a balance (emissions produced by breathing biomass are set off by the carbon fixed), or if it is a net emitter (it degrades more biomass than it produces, thus contributing to increase the concentrations of greenhouse gases.)

The network of organisms that consume biomass and oxidize it to CO_2 (to extract the energy contained by the chemical bonds of organic molecules) includes everyone, from large herbivores (domestic or wild) to the tiniest microorganisms in the soil. Generally speaking, we can say that what is not eaten by one, gets consumed by someone else.

For example, the biomass that would not get eaten by livestock, should it be eliminated, would be consumed by other large herbivores (deer, roebuck) and small herbivores (rabbits, insects), or by fungi and soil bacteria. Therefore, excluding livestock would not necessarily mean that CO_2 emissions would cease.

In fact, it is a well-known fact that grazing barely has any effect on organic carbon accumulation in the soil. In the best-case scenario, the carbon accumulated in the woody biomass could improve, but this would be temporary, and at the risk of increasing the likelihood of fires that return the fixed carbon to the ecosystem rapidly for decades.

The case is different for fossil fuels, as we are speaking about biomass stored for millions of years. Therefore, using fossil fuels implies adding net GHG emissions to the atmosphere, unlike what natural and agricultural ecosystems do, whose net balances are close to neutrality, and where the use of inputs is what contributes significantly to emissions. In the case of grazing-based systems, it is very important to know the real role played by domestic animals in the global balance to establish their emission levels clearly. Only emissions that would be prevented should the productive activity cease must be considered as having an anthropic origin, excluding those that would go on naturally. We define the latter as baseline emissions, and discuss them in detail in the next section.

BASELINE EMISSIONS OF MANAGED ECOSYSTEMS

The purpose is therefore to estimate the value of total GHG emissions in the absence of domestic animals, and compare it to the level of emissions including extensive farming, to see if grazing does indeed generate emissions, and if it does, to what extent. In absence of grazing, pasture biomass will be processed by other consumers. We also need to bear in mind that wild ruminants do not follow grazing plans, so their use of pastures is less regular.

The biomass that they fail to eat accumulates in the ecosystem, usually as wood and cellulose. In absence of the removal task carried out by domestic herbivores, a process of shrub encroachment usually takes place. That is, biomass accumulates in the form of shrub wood that thrives thanks to the disappearance of herbivores that kept them under control. The outcome is an outstanding increase in the risk of forest fires. When they happen, all this matter oxidizes violently, emitting huge amounts of greenhouse gases to the atmosphere, which include significant methane emissions.

The main contribution of ruminants to these systems is to transform part of this plant production (particularly lignocellulosic fibers, very hard to digest for other species) into animal tissue thanks to the powerful digestive function of their multiple stomachs. This is how ruminants transform this plant biomass that we cannot eat, directly into food for the rest of the food chain (including humans).

This applies to 70% of the earth's surface used by livestock farming activities: land that is non-arable as it is considered marginal, due to its climate, soils, or unfavorable slopes. These territories may only be used for grazing livestock; other than that, they cannot be used to produce food for the human population. For this reason, it is not valid to compare the agricultural land necessary to produce plant-based food to the one used for animal-based food, as a large share of the Earth's surface can only be used by ruminants and cannot be farmed.

Should these surfaces be broken up for agriculture, they would degrade immediately,

and environmental costs would be much greater than those allegedly avoided by changing animal to plant production. Obviously, this argument only applies to extensive farming that uses lignocellulosic fibers in lands not suitable for agriculture. Not to industrial farming that uses forage, particularly cereals grown in arable land and that do indeed compete with the production of plant-based food.

An additional effect of grazing is that the biomass portion eaten by ruminants that cannot be digested by them goes back to the soil as feces which are voraciously attacked by the group of decomposers, thus returning to the soil numerous nutrients that are made available to plants. In the absence of ruminants, nutrients stay immobilized in plant structures for longer (biomass or slowly decaying matter). This is how ruminants contribute to soil fertility and enhance microbial life, which is key to optimal plant growth and the accumulation of carbon in the whole ecosystem. In fact, numerous studies show that balanced grazing sequesters more carbon in the soil than no grazing or overgrazing (Chen and col 2015).

Logically, greenhouse gases, including methane which makes up the bulk of the emissions attributed to extensive farming, are also emitted in the process, but it is important to consider all the emissions of the whole system and compare them to the baseline (that is, the emissions removing all domestic animals) as explained in Figure 6.

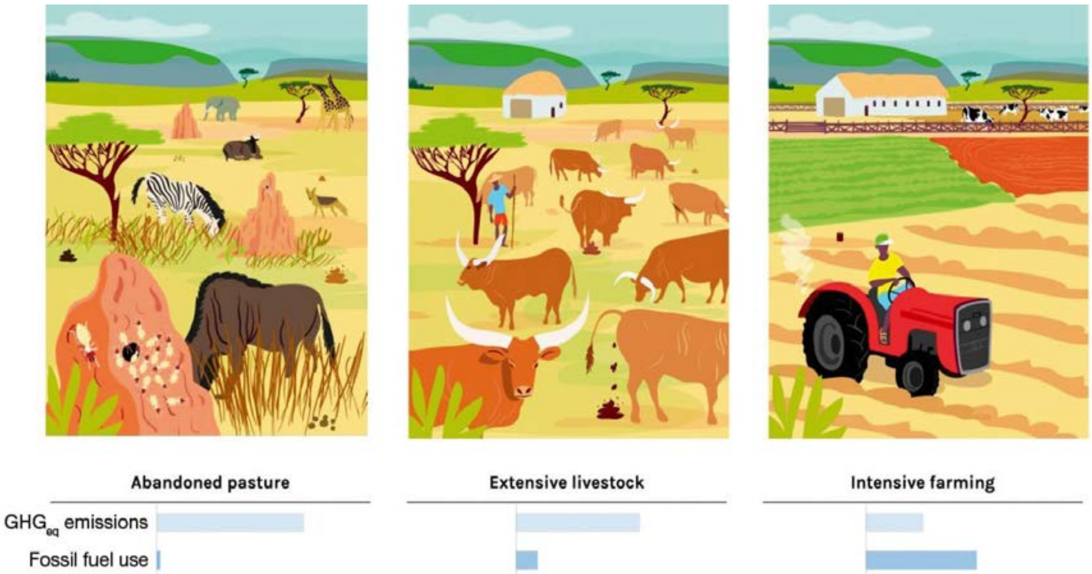


Figure 6: Comparison of emissions from the different stages in a pasture ecosystem. Manzano, P. & White, S.R. (2019) Intensifying pastoralism may not reducegreenhouse gas emissions: wildlife-dominatedlandscape scenarios as a baseline in life-cycle analysis. Published on Climate Research (Manzano & White, 2019), with permission from the publisher.

In essence, if grazing animals are removed to reduce emissions, the result will be more fermentation by wild ruminants, ants, and termites, who also generate large amounts of methane, as well as an increased incidence of forest fires and their emissions, and a drop in the ecosystem's carbon sequestration capacity. The result would be a net increase in emissions. A paper cited in the box below estimates that California's pastures will have

more capacity to sequester carbon in the soil during the XXI century than the forests that would replace them should grazing cease. This result is due, in large part, to the lower fire risk.

The argument of the emissions baseline is very interesting for extensive farming. There are two key references to develop it. One is the scientific paper where Manzano and White set forth the basis of this argument:

Manzano & White (2019). *Intensifying pastoralism may not reduce greenhouse gas emissions: wildlife-dominated landscape scenarios as a baseline in life-cycle analysis*. Res 77:91–97

The other is an editorial article published also by Pablo Manzano in El País in Spanish where he explains it in detail.

We are also quoting two articles in English that elaborate on several aspects addressed in this section, especially on the potential of pastures as carbon sinks:

Chen, W., Huang, D., Liu, N., Zhang, Y., Badgery, W. B., Wang, X., & Shen, Y. (2015). *Improved grazing management may increase soil carbon sequestration in temperate steppe*. Scientific Reports, 5, 10892. https://doi.org/10.1038/srep10892

Dass, P., Houlton, B. Z., Wang, Y., & Warlind, D. (2018). *Grasslands may be more reliable carbon sinks than forests in California*. Environmental Research Letters, 13, 074027.

Another aspect to bear in mind in this connection is efficiency. Extensive farming is often accused of being inefficient in terms of resources (land, nutrients, water, etc.), thus having more emissions than other more industrialized modalities that produce each food unit using less resources (agricultural land, forage, and water). The technical approach backing this type of statement is based on a generalization of processes that hardly holds water when working on a higher level of detail.

Extensive farming is presented as being less efficient because it does not maximize what animals are fed, in the sense that more kilograms of food are necessary to obtain a product unit. This connection between kg of food and product unit is the common way of estimating the efficiency of intensive farms.

It is true that extensive farming uses longer life cycles and that animals, as they are moving and remain outdoors, use more energy in their own metabolism and less in producing meat or milk. But a flaw in this argument is to equate the food provided to grazing animals to what confined animals eat. Ruminant grazing relies on natural vegetation rich in vegetable fibers (cellulose and lignin), which are indigestible for other species, as the basis of the diet. The main advantage of goats and sheep is that their production is based on tough, hard to digest fibers that are useless as human food and therefore, do not compete with it. Logically, the transformation process is much slower and requires more energy, but this is because the raw material is totally different and of much lower quality.

Contrary to the initial claim, considering the type of fibers that ruminants eat, the most abundant and less useful for human food, these animals are incredibly efficient compared to industrial livestock, simply because the latter does not transform raw material. Intensive livestock feed relies basically on concentrated products composed of cereals, soy, and other legumes.

This type of substances is analogue to the ones used for human nutrition, so their production competes directly with food production, unlike pasture-based animal feeding, whose base material is indigestible for people.

Something similar applies to the occupation level and land management. Grazing is accused of being inefficient in terms of land use, as it requires much larger lands than industrial farming. However, the latter takes up its land base exclusively—both the space where the farm is located as well as the fields used for growing feed crops can only be used for that activity, greatly limiting alternative or complementary uses.

In contrast, even if extensive livestock requires more land, it allows the coexistence of various uses and productions simultaneously (pasture, firewood, fruits, honey, tourism, hunting) in conditions compatible with high environmental quality and biodiversity levels.

The use of other natural resources, mainly water and soil, follows a similar pattern. Water consumption in extensive farming integrates with the water cycles in its land base. The main source of water is rainfall and runoff in the territory (ponds, brooks, and local water currents), and is immediately returned to the environment where it came from upon its use, closing the natural water cycle.

Therefore, use is non-exclusive and does not degrade the resource. By contrast, industrial facilities require supply, pipes, and facilities, making exclusive and privative use with an associated environmental impact. Besides generating wastewater that requires additional treatment due to its high level of biochemical pollution, and that has associated emissions.

To sum up, while it is appropriate to talk about resource consumption (water and soil) in connection with industrial farming, in the case of extensive farming we can only talk about the use of resources, as these are not depleted and there is no competition with alternative uses.

A paper published in the Agricultural Systems journal entitled I*Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems* shows how a grazing-based farm can, upon the adoption of an adequate management model, have a global positive behavior with regards to climate change. The farm in the research sequesters more carbon than it emits, even considering that it carries out activities deemed exclusive of intensive farming, like feedlot feeding.

CLIMATE CHANGE EFFECTS ON EXTENSIVE LIVESTOCK FARMING

Climate change affects livestock production in direct and indirect ways. The most important impacts involve animal health and wellbeing, productivity, production, quality and seasonality of pastures, and grazing planning.

Rising temperatures cause thermal stress on animals, which involves a series of negative impacts, i.e. growth and production reduction, reproduction rate decrease, and mortality rate increase. Thermal stress also reduces animal resistance to pathogens, parasites, and

vectors, since rising temperatures favor their overwintering survival. Thus, multiple stress factors are considerably affecting the production, reproduction, and immune status of the animals.

Increasing rainfall variability causes drinking water scarcity, the rise in the incidence of animal pests and diseases, and changes in how the latter are distributed and transmitted. It also affects pasture composition and yield, and forage quality.

There is no doubt that assessing the consequences of global change on extensive farming is a complex task, considering the diversity of livestock systems that may be affected differently by climatic variations.

The main expected effects of climate change on extensive livestock are outlined in the table below, extracted from a 2012 study by the Regional Government of Andalucía (Junta de Andalucía, Spain) on adaptation:

Effects on livestock due to thermal stress caused by an increase in peak temperatures and the period in which they exceed the thermal comfort threshold for each species.
Animal mortality caused by thermal stress.
Drop in livestock production caused by animal discomfort and diet imbalance that reduces livestock's intake.
Reduction in neonatal mortality of lambs, kids, and calves due to rising temperatures that limit cold periods when neonatal mortality is greater.
Reduction of pasture availability caused by the aggravation of the drought pattern.
Reduction of pasture availability caused by an increase in the frequency and intensity of torrential rain that aggravates rainfall erosive potential.
Reduction of pastures stocking rate as consequence of a productivity drop.
Effects on the livestock insurance sector caused by the increase in the population affected by caloric stress.
Increase in production costs to keep livestock in adequate hydration, ventilation, and temperature conditions in intensive farms.
Reduction in the diversity of livestock species having a hard time to adapt naturally to climate change. In the long run, this may lead to their extinction.
Change in pest and disease patterns due to variations in the temperature and rainfall regime.

Tabla 3: Main effects of climate change on livestock. Junta de Andalucía (2012)

In addition to the effects caused by rising temperatures, drought periods, and extreme weather events, there are some non-climate factors that increase extensive livestock's vulnerability to climate change, like livestock sedentarization, the loss of communal lands and practices, or the loss of traditional knowledge on sustainable management and indigenous breeds.

The report Impactos, vulnerabilidad y adaptación al cambio climático en los sistemas extensivos de producción ganadera en España (Impacts, Vulnerabilities, and Climate Change Adaptation in Extensive Livestock Systems in Spain) edited by the Spanish Climate Change Office and the Ministry of Agriculture, Fisheries and Food in 2016, written by Agustín Rubio and Sonia Roig is to our day the main collection of information on extensive farming and climate change in Spain, that includes not only the main effects detected, but also a broad range of mitigation and adaptation strategies.

The Estudio básico sobre adaptación de la ganadería al cambio climático (Basic Study on Livestock Adaptation to Climate Change) published by the Junta de Andalucía makes no distinction between extensive and intensive farming, but still offers a good approach in terms of adaptation, so it is interesting in the context of the South of Spain.

ADDRESSING CLIMATE CHANGE: ADAPTATION AND MITIGATION STRATEGIES

El pastoreo es considerado, a nivel global, Grazing is considered globally not only as a key activity for green economy and the development and wellbeing of millions of people (as renowned international bodies like FAO or UNEP recognize), but also as a tool in the fight against climate change.

Some facts that speak for themselves are grazing's historic capacity to adapt to social and environmental variables, as well as its resilience and the role it has played in land management and governance. Mobile pastoralism is a way of life that has evolved in environments with high levels of climatic uncertainty (deserts, arid zones, mountains, tundra, etc.) developing countless strategies to ensure survival and profitability, to adapt, and to manage natural risks. These skills turn it presently into a clear reference for other activities seeking adaptation and mitigation strategies for climate change.

Some key aspects of pastoralism in relation to its adaptation to climate change are inherent to the productive model. The most obvious one is mobility. Being mobile, pastoralism can move away from some imminent climate catastrophes like droughts or peak temperatures, seeking shelter in lands with better conditions. It also makes it possible to manage food availability, moving animals in search of optimal pasture conditions, and ensuring pasture rest periods.

Lastly, it makes it possible to harness diverse and far away resources, as well as to approach markets physically at the right time for marketing products. Transhumance systems, as short and long-term mobility strategies, are characterized by the highest adaptation capacity, since their routes take into consideration the great climatic diversity of the lands they cross.

Another key characteristic for adaptation is the broad range of land resources that can be used non-exclusively, helping optimize what animals eat and adjust it to the climatic

The work on Pastoreo móvil en el Mediterráneo (Mobile Pastoralism in the Mediterranean) published by the Mediterranean Consortium for Nature & Culture (MCNC) signed by Pablo Manzano and Concha Salguero, collects arguments and evidence that pastoralism is a key element to fight climate change, especially in regions subjected to very irregular climate conditions, like the Mediterranean area.

Besides this assertion, the work underpins with very solid arguments the need to generate political changes to harness this activity's full potential in terms of climate change adaptation and mitigation and providing services that benefit the society at large.

characteristics of each moment. In this connection, the use of communal spaces and public lands, as well as access to resources that are temporarily not used for crops or other activities, must be emphasized.

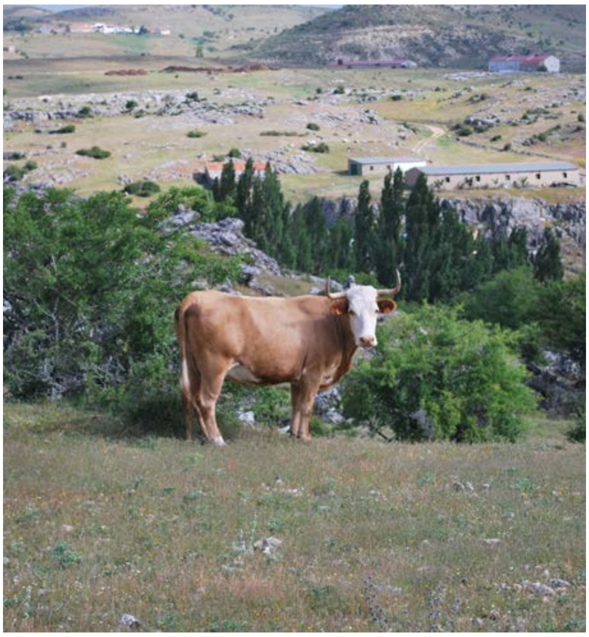
Therefore, extensive farming can access a large set of natural resources, thus optimizing animal feeding, both in terms of amount and quality, and the correct management of pastures. In this regard, in addition to pastures we must mention the use of stubbles, undergrowth, wild fruit like acorns, and shrubland.

Indigenous breeds are another essential element, since they are not only adapted to the local climate, but also to community practices. This does not mean that these are static varieties, but that farmers themselves keep improving them and adapting them to a changing reality.

Risk management is another typical characteristic of pastoralism that is fundamental for its adaptation. The possibility to move converges with the option to readjust the heard size rapidly to prevent risk situations. For example, animals can be sold in the event of a protracted drought, thus reducing the herd size to face the need to buy feed for the remaining animals.

In better times, the number of replacement animals raises to increase the herd and harness abundance. There are other risk-connected strategies, like agricultural insurance, that may contribute to increasing resilience and improving the adaptation of this type of livestock.

Additional adaptation proposals include more specific measures, like having more diverse diets based on wild plants and



legumes, less methanogenic, richer in protein, fatty acids, and tannins. Other measures involve enhancing the land base and promoting forage self-reliance, which increases the quality of the production to help work with less animals that have higher added value.

Also, along the lines of practical interventions in pastures, it is important to implement silvopastoral systems with more trees and shrubs and an optimized management of biomass, increase the proportion of legumes for our pastures to have a lower C/N ratio, and integrate agricultural and livestock productions following circular economy criteria.

In this same regard, and to face vulnerability, it is key to recover and maintain in good condition livestock routes, communal lands, and livestock mobility (long and short transhumances, nomadic...), as well as to diversify the breeds and varieties kept, choosing the most adaptable and resilient ones, of which several indigenous breeds are a great example.

Numerous projects in Spain and Europe have started to address the adaptation (and mitigation) potential of extensive farming. The Life Live-ADAPT project, heavily involved in the edition of this report, is worthy of mention. The Life Regenerate project is exploring climate change adaptation practices in the Iberian dehesas. Gerardo Moreno, from the University of Extremadura, outlines soil, pasture, and tree management proposals in the Boletín nº 16 (pp 16-24) de la Asociación Nacional de la raza Retinta (Bulletin 16 (p 16-24 of the National Association of retinta Breed)).

Also, the Cátedra de Agroecología y Sistemas Alimentarios de la Universidad de Vic (Chair of Agroecology and Food Systems of the University of Vic) with support from the Fundación Biodiversidad started a project to identify how people working in extensive farming in Spain adapt to climate change. Their explanatory video on the subject is an obligatory reference to raise awareness on the role of extensive farming in the fight against climate change.

Other European and Spanish projects connected to the topic are the Infoadapta-Agri project, promoted by the Unión de Pequeños Agricultores UPA (Small Farmers Union), the Life Agri-ADAPT project, with participation from Fundación Global Nature or Life Polyfarming.

The great advantage of grazing is that it can improve not only the management of animals, but also of pastures. Integrating grazing into local ecological processes helps to devise an adaptation mechanism that is also ecosystem-based, consisting in diversifying structures and increasing the biodiversity of the different types of pasture to increase their own resilience, and thus that of the whole pastoralist system.

The complexity and dynamism of pastures, especially grass pastures, ensures rapid response and adaptation to environmental conditions, both in terms of the current variability as well as in the face of medium and long-term future climatic scenarios. Pasture management—including both grass and woody pastures—in terms of increasing the diversity of species that compose them, the extension of their productive periods, the ratio of legumes, the enhancement of their edaphic properties, etc. boosts their adaptation capacity remarkably. Additionally, improved pastures increase their carbon storage capacity, thus making it possible to address adaptation and mitigation simultaneously.

In all cases, pastoralist systems have great mitigation potential. This is mainly because pastures and similar ecosystems store large amounts of carbon in the soil, appearing as one of the largest long-term carbon sinks. By contrast, pastures that are degraded or plowed, often as a result of the intensification of livestock farming, may have an equally remarkable opposite effect, emitting carbon to the atmosphere. Pasture's carbon storage potential is widely covered in the IPCC report on soil.

Given this situation, sustainable pasture management is an essential action to mitigate climate change; and adequate pasture planning, including keeping an optimal stocking rate at all times and adequate grazing and rest periods, is fundamental to adopt a long-term mitigation strategy, particularly in arid and semi-arid zones, in Mediterranean environments and in marginal territories.

Another aspect connected to this is that pasture's potential to capture carbon is closely linked to other climatic factors, like seasonality or water availability, which means that practices aimed at improving water cycles in pasture soils or extending growing seasons are also important mitigation strategies.

This joint consideration of the two ways of facing climate change, through adaptation and mitigation, is one of the main abilities of grazing in the context of climate change.

The graph below, adapted from Marta Rivera-Ferre's and other scientists work and used as reference in the Live-ADAPT Life projects, shows the joint potential of various proposed actions to face climate change adaptation and mitigation needs in the context of extensive farming simultaneously.

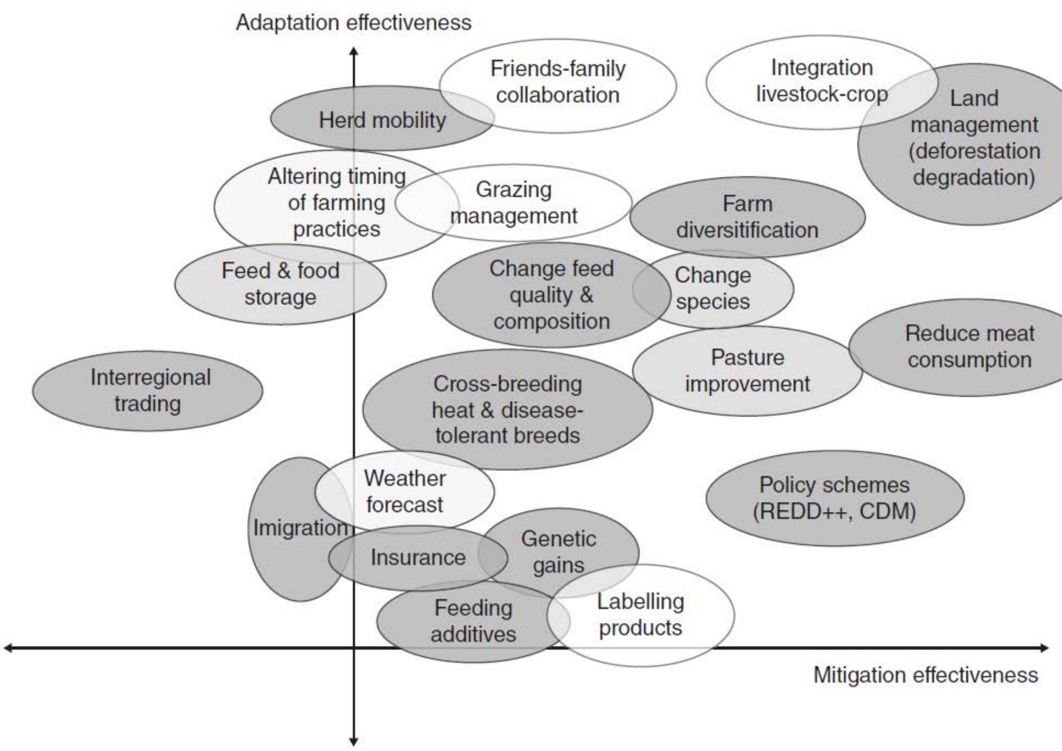


Figure 7: Effectiveness of different adaptation and mitigation options. The intensity of the color implies the difficulty in implementation or cost or trade-off involved. Valorization is qualitative: clear gray, easy implementation, low trade-offs; hard gray, difficult implementation, high trade-offs. dapted from Rivera-Ferre et al. (2016) Re-framing the climate change debate in the livestock sector: mitigation and adaptation options. WIREs Clim Change 2016. doi: 10.1002/wcc.421

E Some of the management changes that are being implemented to improve climate change adaptation include testing new ways of storing water (Keyline design) and strategies to reduce evaporation in ponds, for instance, by introducing automatic drinkers. Moreover, forage hedges and edible shades are being tested, the management of silvopastoral systems is being improved, more resistant pasture species are being sowed, larger rates of leguminous species are being introduced, and pasture biological rhythms are being respected. It is also important to advance in multifunctionality

LESSONS LEARNED

and towards closer connection, even integration, with crops.

Extensive farming is, by definition, a productive sector constantly and dynamically adapting to the characteristics and limitations of the systems based on pastures and mosaics.

From the arguments mentioned previously in this report, we can conclude that extensive livestock farming is not a problem currently contributing to climate change, but rather a victim of it and part of the solution. Fighting against the challenges and disparagement that plague extensive, pasture-based farming requires promoting good practices in the sector, increasing social and political support to extensive production, enhancing the public and private goods and ecosystem services that it provides, and ensuring the sustainability of its uses.

Additional issues to climate change are really complicating the situation of extensive farming in southern Europe. One is generational renewal, insufficient to maintain the activity. Growing numbers of people, with diverse ages and backgrounds, are moving to the rural world, but they have not been taken into consideration yet in agricultural policies. Training and supporting these newcomers should become a priority and be planned within public policies, as it may be a way to ensure the activity's future to a certain extent, since new generations tend to be more open to changing the productive model and capable of developing new, final user-based business models, formulating more sustainable livestock systems and new organizational models, and improving the connections between the farms and local communities, particularly in areas with considerable land abandonment and/or depopulation. Being a livestock farmer involves much more than owning livestock, it means being part of rural society and revitalizing it.

In this connection, the role that women farmers play now and may play in the future is key, improving the proximity with consumers and paying attention to innovation, transmission of knowledge and traditional know-how. All in all, they do their job with a perspective that goes far beyond sheer productivity. The horizon proposed involves clearly advocating extensive farming, not only as a consumption choice, but also as an option that manages, maintains, and recovers the landscape.

Other of the most obvious adaptations that needs to be addressed in the context of the relation between climate change and extensive farming is in the scope of food. At this point, there is no doubt that a radical shift in the food model is necessary to fight climate change.

That is, a more sustainable, agroecologically-based food system that values and prioritizes local food, products that contribute to climate change mitigation and adaptation, that favor local jobs, economy, and culture, that are integrated in the local ecological cycles, and that generate relevant ecosystem services that may be as important as the carbon footprint itself.

Lastly, in a context where it is necessary to reduce meat consumption in Europe, it is essential to opt for meat that has a clear climate change mitigation potential, in addition to offering other ecosystem services.

To this end, it is necessary to take firm steps toward the differentiation of extensive and pastoralist-based products in the markets, to help consumers decide what to buy. If consumers have higher levels of information and awareness, so that they can make real decisions, the feasibility of farms will improve, and farmers will be better suited to face climate change challenges.

For this, extensive farming must avoid being just one more link in the chain of industrial meat production, advocating production models based on grass-fed livestock with better management of their own forage resources.

Animal welfare standards and the possibility of certifying meat and other grass-fed products provide the opportunity to access a clearly differentiated market niche willing to pay for low (or neutral) emissions products and the environmental services that extensive farming offers to the society and territory.

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