A Narrative Review on Intensive Animal Farming: a Planetary Health Perspective on Co-benefits

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Abstract

Intensive animal farming is one of the major industries contributing to the current global poly-crisis. The industry relates to the farming of crowded groups of animals, often in an indoor environment using external food sources and often growth promoters, antibiotics and other rather “unnatural” products. There is a necessity of understanding the complex relationship of humanity with our surrounding ecosystem and how our interaction with the planet reflects back on us and our health. Co-benefits are additional beneficial outcomes of an action, which are often beyond the direct benefits of the action. Research on co-benefits is gaining popularity as it aims to give the reader and policymakers a more complete understanding of a suggested action, often including environmental, social and economic aspects. The paper aims to answer the following research question: “What are the co-benefits relating to environmental and human health of reducing intensive animal farming; from a planetary health perspective?”. A wide range of literature has been used to build an argument on the importance of reducing intensive animal farming in obtaining a co-benefit for human and planetary health. The paper identifies the following co-benefits relating to the reduction of intensive animal farming: Limiting human-induced climate change, promoting healthy (water- and soil-dependent) ecosystems, sustaining our interdependent relationship with the ecosystem and its services, increasing animal welfare, limiting health risks caused by exposure to antibiotics, antibiotic-resistant bacteria and (synthetic) hormones, limiting the risk of new emerging zoonoses, suggesting a healthy nutritional shift limiting health risks associated to diet and limiting food insecurity. Intensive animal farming, representing the efficiency-based society, might need rethinking to obtain co-benefits and to achieve planetary health.

Keywords: intensive animal farming, co-benefits, planetary health, human health, environmental health

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A global poly-crisis

The various interdependent crises of our time can be described as a "global poly-crisis" (Lawrence et al., 2022). The climate and biodiversity crisis, pollution, (increased risk of) pandemics, and food and energy insecurity are some examples of singular crises, together forming a global poly-crisis affecting global health. Intensive animal farming is one of the major industries contributing to this global poly-crisis (Schuck-Paim, 2020). Intensive animal farming relates to the farming of crowded groups of animals, often in an indoor environment using external food sources and often growth promoters, antibiotics and other rather "unnatural" products (Eijrond et al., 2019). Research by Bar-On et al. (2018) estimated that nearly 60 percent of the biomass of all mammals walking the planet is raised for food purposes. Considering the scale of the industry, the impact and involvement of the industry in different crises are significant. Intensive animal farming is often associated with low animal welfare and tidily connects to topics such as climate change, land and atmosphere disruption, food shortages and human health. 14,5 percent of all human-induced greenhouse gas emissions are caused by the livestock industry, making it one of the main contributing factors to human-induced climate change (Sakadevan & Nguyen, 2017). Intensive forms of animal farming facilitate the transmission of diseases or infections into human society, called zoonoses (Jones et al., 2013). While dealing with global food shortages, 60 percent of all the biomass harvested is used for livestock production, a very inefficient process (Sakadevan & Nguyen, 2017). Meanwhile, the intensive animal farming industry is responsible for using high amounts of antibiotics. Antibiotic resistance is an increasing problem, forming serious concerns for human health (Berendonk et al., 2015). The sum-up of problems relating to the intensive animal farming industry might show the complexity of the industry and how it relates to other fields.

A planetary health perspective on co-benefits

The impacts of the intensive livestock industry can be further investigated from a planetary health perspective, as it touches upon human health and the health of the natural system supporting humanity. Planetary health aims to understand our relationship with the planet and how human impacts on the natural environment are again negatively affecting human health (Pongsiri et al., 2017). Co-benefits are often discussed when approaching a topic from a planetary health perspective. Co-benefits are additional beneficial outcomes of an action, which are often beyond the direct benefits of the action. Research on co-benefits is gaining popularity as it aims to give the reader and policymakers a more complete understanding of a suggested action, often including environmental, social and economic aspects (Mayrhofer & Gupta, 2016). This paper will mainly focus on the co-benefits relating to environmental and health aspects. There is a lot of research on climate policies and their co-benefits, which are unfortunately often not well-considered by policymakers (Karlsson et al., 2020). To give an example of co-benefits: the reduction of intensive animal production leads to a lower amount of farmed animals, leading to lower consumption of animal products, suggesting a nutritional shift, benefiting human health (Rust et al., 2020). The various health benefits represent some of the co-benefits of reducing intensive animal production. The paper by Rust et al. (2020) also suggests other social, economic and financial co-benefits to reducing meat intake, of which some will be discussed in this paper as co-benefits to the reduction of intensive animal farming. The co-benefits cover the field of human health and the health of our environment, sustaining humanity. More co-benefits can be discovered throughout this research, but considering the scope of the research and the scope of the topic, not all factors can be discussed.

Research question

The paper aims to answer the following research question: *"What are the co-benefits relating to environmental and human health of reducing intensive animal farming; from a planetary health perspective?"*. The research question aims to provide the reader and policymakers with a dense overview of the impacts of intensive animal production beyond the often quite limited connections taken into account and how this reflects back to human health. The term and concept of "planetary health" is gaining popularity in recent years (Prescott & Logan, 2019). There is a necessity of understanding the complex relationship of humanity with our surrounding ecosystem and how our interaction with the planet reflects back on us and our health. The research question is relatively broad but should cover most of the important sub-topics relating to intensive animal farming.

Intensive animal farming

Definition

The paper uses both terms 1) intensive animal farming and 2) intensive livestock farming. Both terms are often used to describe a rather similar phenomenon. Intensive livestock farming refers to livestock farming without its own feed production (Eijrond et al., 2019). Whereas intensive livestock farming focuses on livestock only, intensive animal farming concerns all animals farmed in an intensive manner. Different sources use slightly different definitions of livestock, some include poultry in their definition whereas other definitions are limited to exclusively mammals (cattle, horses, sheep and goats). As intensive poultry farming, but also other intensive forms of farming such as aquaculture have significant impacts on a global level, the definition “intensive animal farming” can be used to discuss the overall topic of intensive farming, not limited to livestock. As the term “intensive animal farming” is most inclusive, the paper will use this term to discuss the overall topic. Specific subtopics and sections might use the term “intensive livestock farming” when referring specifically to the farming of livestock or when using sources focussing on exclusively livestock.

Different criteria are used to define intensive animal farming. The European Commission defines intensive farming based on the number of animals farmed (European Commission, 2013). When a farm has more than 40.000 chickens or more than 2000 pigs the European Union defines it to be intensive. Among organisations, these numbers vary and in practice, the exact number might be more of an indicator than a direct representation. The intensiveness of farming is difficult to describe in binary terms and can better be described using a continuous scale. The process of intensive animal farming aims to be “space efficient”, having many animals on a small surface area. As mentioned, intensive animal farming is not dependent on its own land for feed production but uses external resources to feed the animals. For example, milk-production cows (grazing in the field) are not included in the definition of intensive animal farming, as they rely on their own local food resources, whereas most pig farms use non-local resources (such as soy).

External feed production

As intensive animal farming is dependent on external feed production, soy or other products are produced in other (often distant) countries after which they are shipped or flown around the world to feed the locally farmed animals. *Figure 1* shows that in 2018, only 20 percent of the global soy production is directly used for human consumption, whereas 76 percent is used for animal feed. Of all soy production over one-third (37 percent) is used for feeding poultry and over one-fifth (20,2 percent) is used for feeding pigs.

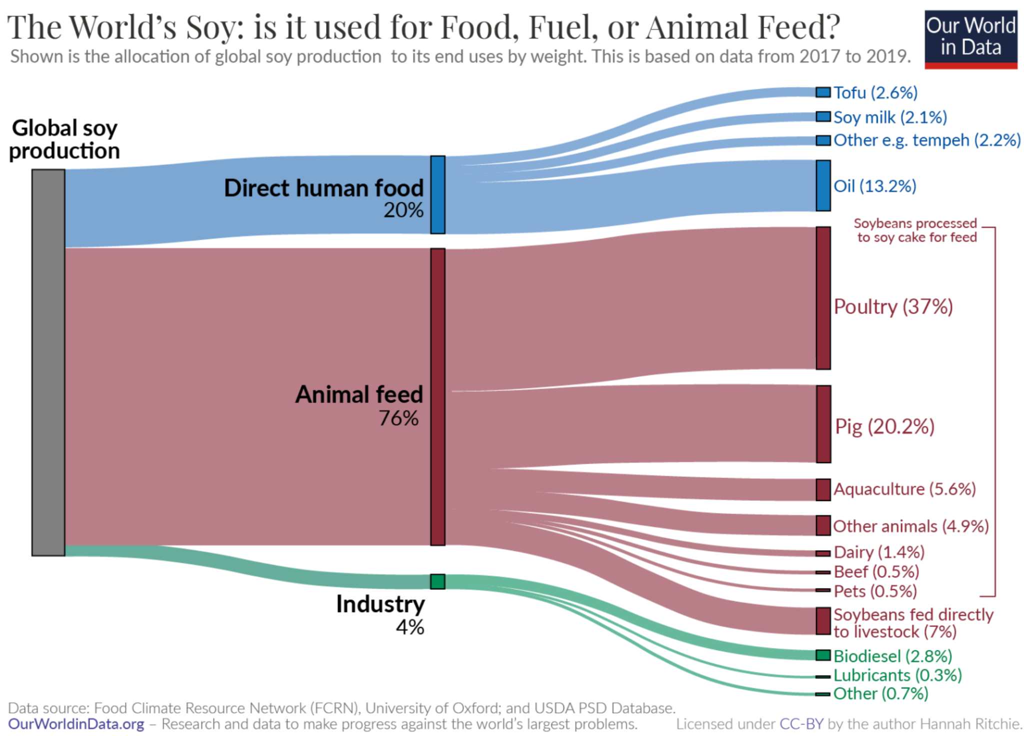

Figure 1: Allocation of global soy production (Ritchie, 2021a).

The indirect human consumption of soy products seems to have a bigger impact than direct forms of consumption. Soy production directly relates to deforestation as the forest is being cut down in order to make space for the growing of soy. The two biggest production countries of soy are the United States and Brazil (Tyukavina et al., 2017). Brazil, being home to the Amazon rainforest experiences the consequences of soy production through its loss of forest area. When looking at the main causes of deforestation in the Amazon area, *Figure 2* shows that pasture has a major impact.

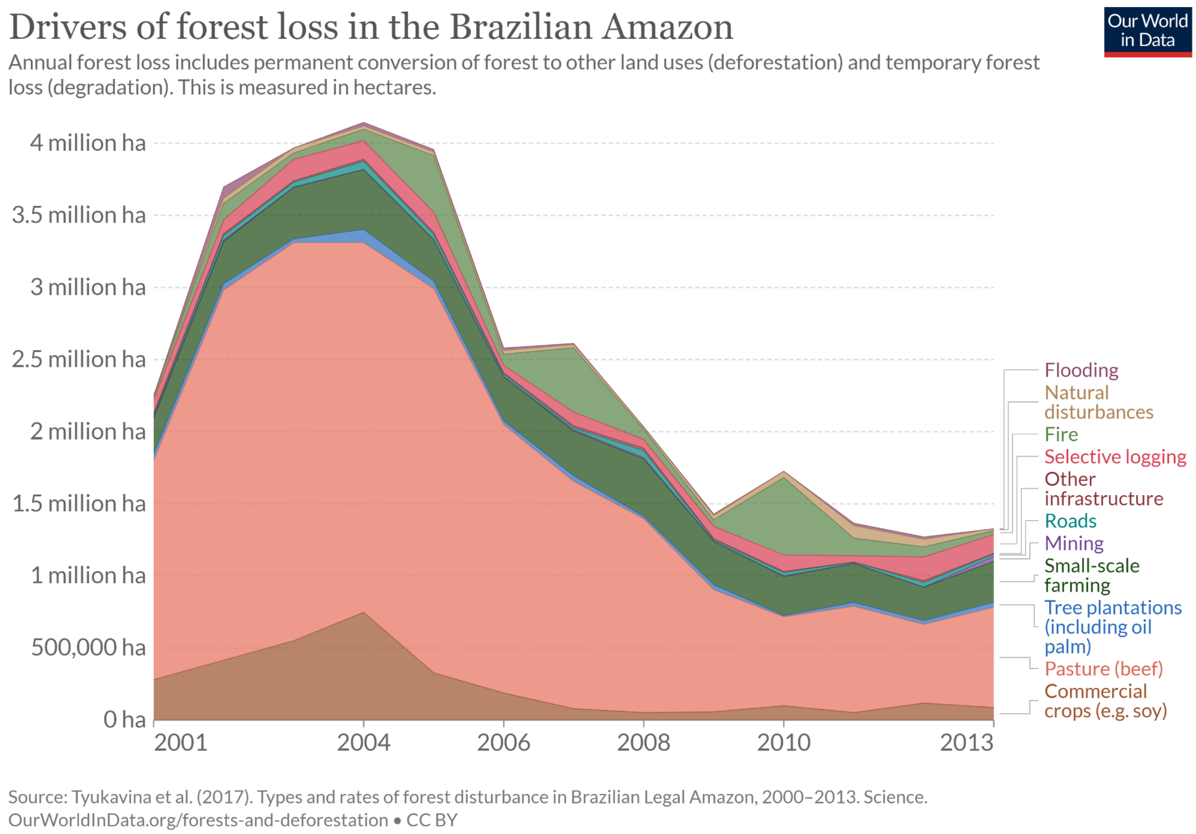

Figure 2: Drivers of forest loss in the Brazilian Amazon (Ritchie, 2021a).

Pasture is land used for the grazing of domesticated livestock, such as sheep, cattle or horses. Since this paper aims to focus on intensive animal farming it will not take these forms of farming into consideration as the animals in this scenario are not dependent on external food sources. Even though the paper focuses on intensive forms of animal production, it is important also to consider the impact of animal production in general.

Concepts and definitions

Ecosystem services

Ecosystems provide ecosystem services, which are benefits or goods provided to society by the ecosystem and its wildlife (Jackson et al., 2013). As humans are dependent on a healthy ecosystem to provide us with resources. The endangering of our ecosystem is a threat to human health. There are provisioning (food, water, energy and more), regulating (f.e. Disease climate and water quality regulation), cultural (f.e. Education and science) and supporting ecosystem services (f.e. Nutrient cycling) (Jackson et al., 2013). Some of the environmental impacts related to intensive farming directly connect to human health, such as water and air pollution, but other factors impact the ecosystem, limiting the ecosystem to optimally provide ecosystem services. The health of the ecosystem has to be considered when discussing human health.

Water quality

Water quality criteria aim to describe the conditions under which it can sustain a healthy system of aquatic organisms and its potential for human consumption of drinking water (Ahuja et al., 2014). The water should contain the essential nutrients to sustain aquatic life. Not only the absence of certain nutrients can cause problems for aquatic life, but also an overdosing of certain nutrients or the presence of toxins. The pollution of phosphorus and nitrogen describes such an overdose of nutrients.

Aquaculture

Aquaculture is defined as: “The cultivation of aquatic organisms in controlled aquatic environments for any commercial, recreational or public purpose.” (What is aquaculture?, 2016).

The aquatic organisms farmed in aquaculture include molluscs, crustaceans, fish, algae and other organisms.

Zoonoses

I quote: “A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans” (World Health Organisation: WHO, 2020). Ebola, MERS, SARS, avian influenza, TB, toxoplasmosis and rabies are among other well-known zoonoses.

Methods

Study Design

The research paper is written in the form of a narrative review. The overall topic of co-benefits relating to reducing intensive animal farming is divided into two sections; environmental impacts and human health impacts of reducing intensive animal farming. Both subtopics are divided into various subtopics. The paper aims to give a clear overview of the co-benefits and possibly identify any research gaps.

Research process

A wide range of literature has been used to build an argument on the importance of reducing intensive animal farming in obtaining a co-benefit for human and planetary health. The paper builds upon the existing literature on the topic, using google scholar to search for articles. As the topic of the paper is rather broad and the gathering of data is not systematic, a high variety of search items has been used. Both the terms “intensive animal farming” and “intensive livestock farming” were used as search items, as both cover the research topic. The subtopics were identified using papers discussing the overall impact of intensive animal/livestock farming. Either of these terms was combined with terms related to the sub-topics, such as “zoonoses”, “human health”, “Climate change”, “water pollution”, “antibiotic use/resistance” and “animal welfare”. The paper approaches the topic from a planetary health perspective. Planetary health connects to different disciplines making it necessary for the research question to include research from different disciplines, including social sciences and natural and applied sciences. The papers used, aim to be recent and still relevant, peer-reviewed and should avoid biases on intensive animal farming. Avoiding biases is important as the topic is quite sensitive and a lot of parties (such as governments and intergovernmental organisations) have specific interests concerning the future of the intensive animal farming industry. When the reliability of relevant research was debatable it was not included in the research. The data gathering was conducted between January 2023, and May 2023.

Environmental impacts of intensive animal farming

Climate change: Methane emissions

14,5 percent of all human-induced greenhouse gas emissions are caused by the livestock industry, making it one of the main contributing factors to human-induced climate change (Sakadevan & Nguyen, 2017). Different sources suggest a different percentage of total greenhouse gas emissions caused by the livestock industry. The paper by Goodland & Anhang (2009) even suggests that the livestock industry is responsible for more than half (51 percent) of all greenhouse gas emissions when taking into consideration all indirect impacts of livestock farming. These indirect impacts for example include the emissions deriving from the transport of livestock and related products, deforestation and feed production. In the fermentation process of an individual animal, there are byproducts. One of the byproducts associated with the fermentation process in ruminant livestock is methane, CH4 (St-Pierre & Wright, 2013). Ruminant livestock have special microbes called methanogens in their rumen, which produce methane as a byproduct of the fermentation process. Ruminant livestock includes sheep, cattle and goats. Methane, like carbon dioxide, is a carbon-holding molecule, that works as a greenhouse gas. Different greenhouse gases absorb different amounts of heat, depending on a variety of factors. As methane traps a set window of radiation with a specific frequency, its presence or absence in the atmosphere has a direct impact on the climate, as other greenhouse gases capture a different window of radiation. Methane is a short-lived climate pollutant. These pollutants have a strong impact on the climate, but they only exist in the atmosphere for a rather short period of time (in the case of methane around 12 years) (Pierrehumburt, 2014). The direct climate impact of methane is therefore relatively big, but its impact is less long-term and therefore a decrease in methane output will have short-term positive effects in battling climate change. Carbon dioxide (CO2) is also emitted by livestock, but since CO2 is a very common greenhouse gas emitted by most other industries as well, it might not be necessary to elaborate much more on this. Intensive animal production aims for high production rates in order to fulfil high rates of (cheap) consumption. Both CO2 and methane emissions are direct products of individual animals, meaning that the higher the number of animals, the higher the emissions by the industry. Intensive animal farming is therefore responsible for large amounts of emissions considering the high quantity of animals farmed. Climate change reflects back on human health, as the health impacts of climate change are significant (Rocque et al., 2021). In the overview of systematic reviews on the health effects of climate change by Rocque et al. (2021) 10 categories of health effects are given. The health concerns in the different papers include infectious diseases, respiratory, skin diseases and allergies, mortality, healthcare systems, mental health, occupational health and injuries, pregnancy and birth, cardiovascular and neurological, nutritional, and other health-related outcomes.

Water pollution

The water quality of natural water systems close to livestock production is decreasing and during the last decades with intensifying forms of livestock production, more agricultural pollutants have emerged (Mateo-Sagasta et al., 2017). The intensification of animal farming includes the increasing use of hormones, vaccines, medicines and antibiotics. Water can transport these pollutants from farms to nearby ecosystems, affecting not only the quality and values of water and soil systems but also the individuals directly dependent on the local ecosystem. Pathogens as well are being spread from farms to surrounding areas, sustaining the emergence of zoonoses. Intensive animal farming, therefore, forms a serious problem for the water quality in natural systems. One-third of phosphorus and nitrogen freshwater pollution is caused by animal farming (Rust et al., 2020). The input of these pollutants impacts the quality of the water body. An ecosystem is balanced when it sustains itself. Input and output form a vulnerable and interdependent connection that should conserve the balance within the ecosystem. The run-off of phosphorus and nitrogen (deriving from phosphorus and nitrogen-holding products such as animal feed and fertiliser) increases the phosphorus and nitrogen values of the waterbody. The increased values can lead to increased growth of algae and water plants, lowering the oxygen level of the water endangering and eventually killing many of the organisms within the ecosystem, a process called eutrophication (Khan & Mohammad, 2014). Eutrophication describes the nutrient enrichment of a water body leading to increased plant and algae growth, eventually leading to low oxygen levels, leading to the death of most aquatic animals in the local ecosystem. Intensive animal farming keeps animals in high amounts, unbalanced with the area of land. Often the number of animals intensively farmed exceeds the capacity of the land they are farmed on (Biagini & Lazzaroni, 2018). The land area is therefore often not able to assimilate the animal waste, increasing nutrient run-off. In a case study in Italy, the water quality was measured to be most problematic in the areas performing intensive forms of animal farming, exceeding the capacity of the land area to take up the nutrients (Biagini & Lazzaroni, 2018). In the north of the country intensive animal farming is common, with a main focus on dairy cattle. As expected, the area has to deal with low water quality. Apart from water pollution throughout farm run-off, the livestock industry uses high amounts of fresh water for the production of livestock. Nearly 20 percent of the global freshwater use is used for animal agriculture (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, 2019). The water use for the growing of crops is high and many farm animals are dependent for their feed on crop farming. The water used for the growing of crops is much higher than for products such as grass which can be naturally grazed. Intensive livestock farming which is dependent on soybeans, corn and other crops is therefore associated with a higher water use than less intensive livestock farming, allowing the animals to graze.

Aquaculture

In aquaculture, aquatic organisms are kept in a closed-off environment where the production process can be controlled (What is aquaculture?, 2016). Aquaculture often still interacts with the surrounding waters through the use of open systems in aquaculture. In an open system, water is able to travel from within the production area to the open sea or other natural water bodies/streams and the other way around. Aquaculture relies on the input of nutrition. But the input does not only include nutritional purposes (in the form of feed) but often also antibiotics, pesticides and other ecosystem-harming chemicals. Different contaminants include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and organochlorinated pesticides (OCPs) (Justino et al., 2016). PCBs are human-made organic chemicals that hold chloride, hydrogen and carbon. PAHs exist naturally in products such as gasoline and oil and are created in the burning process. OCPs are hydrocarbons that are chlorinated and thus hold chloride. The pollutants can eventually end up in the human body. Depending on the kind of pollutant, aquatic animals store the toxin in their tissue. The toxins move up in the food pyramid as organisms on top of the food chain consume a relatively great amount of organisms lower in the food chain (Walker & Livingstone, 2013). “Persistent organic pollutants (POPs) are chemical substances that persist in the environment, accumulate in the food web, and pose a risk of adverse effects in humans and wildlife” (Lallas, 2001). Both PCBs and PAH can infiltrate the aquatic ecosystem and can eventually end up in the human system through the consumption of fish or other aquatic organisms (Pheiffer et al., 2016) (Walker & Livingstone, 2013). As these persistent pollutants are resistant to biological and chemical degradation the amount of toxins in fish and other aquatic organisms on top of the food chain is high. PAHs in marine foods endanger human health, including the risk of cancer related to the intake of food containing PAHs (Balcıoğlu, 2016) (Huang & Penning, 2014).

Health threats related to intensive animal farming

Hormones

Hormones can be used to influence the growth of intensively farmed animals. Just like humans, animals (as well as plants) produce a variety of hormones and similar products (Palacios et al., 2020). Additional hormones can fasten processes in the animal such as their growth. By consuming animal products the consumer also consumes hormones present in the product. Dairy products are meant to support the growth of the young and therefore contain hormones supporting the growth of the specific species. The hormones naturally present in animals and their products may have health impacts on the consumer, but since these are present independent of how intensively the animals are being farmed, it is more relevant for this research to investigate the health impacts of the additional hormones used in intensive animal farming. Two different groups of hormones can be identified, natural hormones and synthetic hormones. Natural hormones are hormones which are naturally produced by animals and synthetic hormones are chemically produced hormones that should copy the effects of natural hormones. Chemicals which mimic the function of hormones are called Endocrine Disruptor Compounds (EDCs) (Almazrouei et al., 2023). Synthetic steroid hormones are also ECDs. The high toxicity of EDCs disrupts aquatic systems forming a great environmental risk and as humans interact with the ecosystem the EDCs also enter the human body. Since the original function of synthetic hormones is to mimic natural hormones, the chemicals can also disrupt hormone biosynthesis, metabolism, or action. This disruption causes changes in normal homeostatic regulation or reproduction.

There are different ways in which humans and animals get exposed to synthetic hormones (Gaddafi et al., 2021). Direct exposure happens to intensively farmed animals directly given the hormones. The industry often uses small hormone-giving implants which they put under the skin on the back of the animal's ear. Indirect exposure mainly happens through the consumption of contaminated products. One way in which synthetic hormones can enter the human body is when consuming meat or animal products derived from an animal treated with additional hormones. Another way in which this can happen is through the contaminated waste of intensively farmed animals. The amount of steroid hormones excreted by all farm animals is expected to outweigh the amount excreted by humans. (Johnson et al., 2006). Research by Johnson et al. (2006) suggests that only a small amount of synthetic and natural steroid hormones deriving from farm animals end up in the aquatic system, but the study focussed their research on the United Kingdom, a country with relatively a lot of small farms. In countries with more intensive farming, the run-off of hormones into aquatic systems is more significant (Ojoghoro et al., 2021). Many intensive animal farms do not have proper on-site wastewater treatment systems. Without proper treatment of wastewater, the water excreted into the environment still contains the hormones excreted by the farm animals. Even when the concentration of certain hormones in aquatic systems is very low and even unmeasurable, it can have a significant impact on the ecosystem (Ojoghoro et al., 2021). The added hormones can create an imbalance in the water and soil system and can eventually lead to serious health effects for humans such as loss of fertility and cancer (Itana & Dugama, 2021). Hormones can enter the body through drinking water or the consumption of other substances derived from contaminated water or soil. Recent research found that growth promoters in livestock impact the pubertal onset age of girls (Gill & Coffin, 2022). The study Compares different countries (countries where growth hormones are allowed and countries where growth hormones are not allowed). The earlier age of pubertal onset has various possible negative health impacts of which a higher risk of cancer, premature pregnancy and an increased risk of cardiovascular disease (Ahlgren et al., 2004) (Adair, 2008). The analysis by Gill and Coffin (2022) argues the long-term effects of the earlier age of pubertal onset include poor behavioural, physical and psychological health outcomes during early adulthood. This is only one specific example of the impact of hormones in animal products on human health, but many more concerns are known and others are still being investigated (Malekinejad & Rezabakhsh, 2015).

In the EU, the use of hormones as a growth promoter has been banned since 2010 and in the United States there are specific regulations indicating which hormones are allowed, but in a lot of countries, these regulations are non-existing (Qaid & Abdoun, 2022). Whereas some sources such as the U.S Food and drug association claim that the concentration of the allowed “added” hormones (such as progesterone, testosterone and oestrogen) entering one's system after the consumption of an animal product is small and irrelevant compared to the naturally occurring hormones in products (US Food and Drug Administration, 2014), other sources warn for worrying health impacts. The EU and the United States have a great disagreement concerning the use and importing of hormone-treated beef, leading to a long-lasting trade dispute (Johnson & Hanrahan, 2010). The EU has conducted a risk assessment and the results suggested possible health risks of hormone-treated meat, confirming their already existing ban on hormone-treated meat. It is important to acknowledge the different impacts of natural and synthetic hormones and that some hormones seem safe to use in the appropriate amounts. A lot of the animal products consumed on a global scale are not being produced in environments with hormone use restrictions, thus health concerns due to hormone use in intensive farming remain.

Antibiotics

To promote growth and to prevent infectious diseases (which are easily spread when many animals share a small inside space) medicines are used (Muthukumar & Mandal, 2017). There are regulations for "responsible" medicine use, such as withholding medicine before slaughter and not using more than the assigned dose. Realistically it is often not the case that the industry works in line with these safety recommendations, affecting both animal and human health (Muthukumar & Mandal, 2017). The EU and the United States have both banned the use of antibiotics in animal farming, but both the poultry and livestock industry often keeps using high amounts (Yue et al., 2021). It is important to consider that these regulations do not exist in most countries and that antibiotic resistance is a global problem.

In 2014 an estimated 700.000 people died due to antibiotic resistance and in 2050 this number is expected to increase to 10 million (O'neill, 2014). When bacteria become resistant to certain antibiotics, infections cannot be tackled using these antibiotics, allowing the bacteria to keep growing, making it very difficult and sometimes even impossible to treat the infection. Over half of the global antibiotic use is used for animal husbandry (He et al., 2020). Most antibiotics in animal farming are used for disease prevention and/or growth promotion, which means that the antibiotics are constantly provided, rather than for a short period of time (He et al., 2020). As the antibiotics are provided over a long period of time, the population of bacteria within the system of the individual has the opportunity and need to adapt and become resistant to the antibiotics. The antibiotics and antibiotic-resistant bacteria within the system of the animal will only start being a problem for human health at the moment they interact with the outside environment and they have the opportunity to spread beyond the boundaries of the farm. Both the spread of antibiotics and antibiotic-resistant bacteria promotes antibiotic resistance in in humans. The increased amount of antibiotics in the human body facilitates the increase of antibiotic-resistance bacteria.

There are multiple ways in which antibiotic-resistant bacteria and antibiotics can spread into human society. One of the main contributors providing this pathway into human society concerns the waste management of livestock (He et al., 2020). The common waste treatment does not fully extract all antibiotic-resistant bacteria. When comparing the removal of antibiotic-resistant bacteria to other fields working with antibiotics, the livestock industry is doing an inadequate job. The waste products of for example the chicken and pig industry contain up to 5 times more antibiotic-resistant bacteria, compared to the waste products of hospitals (He et al., 2020). This poor waste management allows antibiotic-resistant bacteria to appear in natural water and soil systems. The growing presence of antibiotic-resistant bacteria in the system (which we are dependent on and interacting with) facilitates the pathway into the human body, throughout for example inhalation and consumption. The manure of intensively farmed animals can contain antibiotics and antibiotic-resistant bacteria which were existing within the system of the animal (Xie et al., 2018). The antibiotics and antibiotic-resistant bacteria can therefore end up in soil systems through animal manure. Another way in which antibiotic bacteria can end up in the human body is by direct contact with the treated animals (Cho et al., 2012). The research by Cho et al. (2012) compares the antibiotic-resistance in healthy poultry and swine farm workers using antibiotics in Korea. The levels of antibiotic resistance in farm workers were compared to restaurant workers in the same area. The research found a higher prevalence of antibiotic resistance in the workers on the farms (using antibiotics on animals) than in the restaurant workers (presenting the control group, not working with antibiotics). These outcomes suggest that direct contact with animals intensively treated with antibiotics increases the levels of antibiotic resistance in farm workers, while the intensive processes in intensive animal farming require relatively a lot of contact with the animals. Lastly, meat products of animals treated with antibiotics, often still contain concentrations of antibiotics. Research by Ramatla et al. (2017) analysed 150 pieces of raw meat purchased at sale points. Some of the meat products still contained significant amounts of the following antibiotics: ciprofloxacin, streptomycin, sulphanilamide and tetracycline. Both ciprofloxacin and streptomycin were on average detected with amounts exceeding the Codex/SA MRL recommended limit.

Zoonoses

Each year, zoonoses cause millions of fatalities and approximately one billion cases of sickness (Espinoza et al., 2020). Seventy-five percent of all pathogens causing infections and diseases in humans derive from animals and their products (Taylor et al., 2001). Research shows that the intensification of livestock farming leads to increasing population size and density accommodating disease transmission (Jones et al., 2013). *Figure 3* shows the network in which diseases and infections are being spread, leading to the formation of a zoonose.

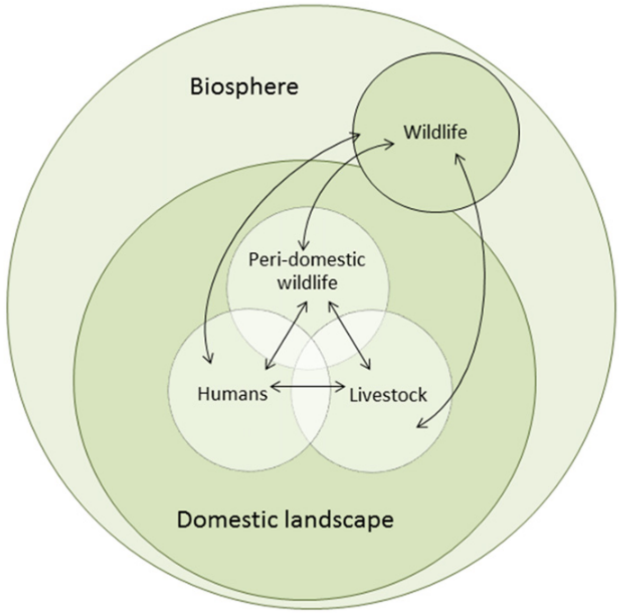

Figure 3: The intensification of livestock farming and its network supporting disease transmission (Jones et al., 2013)

Livestock interacts with wildlife, peri-domestic wildlife and humans. An increase in population size in any of the groups (humans, wildlife, per-domestic wildlife and livestock) increases the risk of pathogens being transferred to humans. The increase in global activity also leads to increased interaction with animals (Bengis et al., 2004). The human-human interaction facilitates the disease or infection to live for a longer time among humanity. The interaction of all actors with wildlife is the main reason for the emergence of Zoonoses and the intensification process of livestock promotes these interactions (Gilbert et al., 2021). *Figure 4* shows our interaction with animals from many different angles and how this relates to the flow of pathogens.

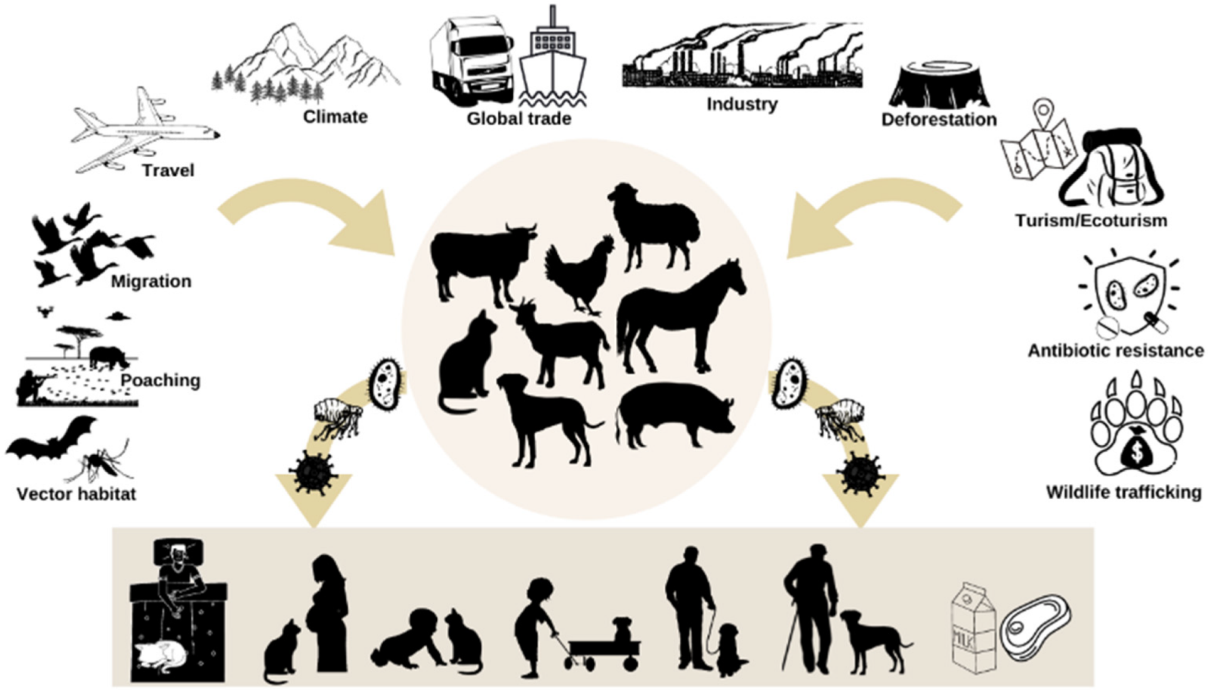

Figure 4: Human interaction and intensification relating to zoonoses (do Vale et al., 2021)

Livestock can be perceived as an amplifier or intermediate host, forming a bridge between wildlife and humans and allowing pathogens to cross into human society (Jones et al., 2013). The increasing population size within the livestock industry, mainly pigs and poultry facilitates disease transmission. Antimicrobials are among other aims also frequently used for disease prevention, which as described in the previous section causes the increase in antimicrobial resistance. The intensification of the industry creates an increased need for human interaction with the farm. There is a lot of vehicle and human movement from and to the farm to support this externally dependent form of livestock production. The more people interact and the more frequent the interactions, the higher the chances of the transmission of pathogens. Intensive livestock production often holds a population with low genetic variation (Springbett, 2003). Research showed that low genetic variation in livestock farming was associated with either an epidemic outbreak or the absence of an epidemic at all, whereas high genetic variation was more often associated with small epidemics. (Springbett, 2003). Intensive livestock production, therefore, has a higher risk of uncontrollable epidemic outbreaks, whereas less intensive forms of farming have a higher risk of a greater quantity of small epidemic outbreaks.

A nutritional shift

A rather direct impact of reducing intensive animal farming is the nutritional shift this would trigger. The health impacts of consuming animal products, with a particular focus on meat products, is a frequently discussed topic. Meat includes many useful minerals, of which zinc and iron, a variety of vitamins and relatively high amounts of protein (Rohrmann & Linseisen, 2016). But apart from these useful ingredients, the health risks seem to outweigh the benefits of meat consumption. Both unprocessed and processed red meat consumption and its relationship to disease occurrence have already been extensively researched and the review of epidemiological studies by Richi et al. (2015) included a variety of studies investigating health risks associated with meat consumption. The paper argues that red meat consumption relates for both men and women to an increased risk of cardiovascular disease, total mortality, type 2 diabetes and colorectal cancer. The paper argues that mainly processed meat relates to these negative health impacts. Processed meat is often red meat which is salted, smoked or cured (Rohrmann & Linseisen, 2016). This is either being done to improve the taste or to better conserve the product. Sausage, ham and bacon are some typical examples of processed meat. A large-scale study included five-hundred thousand participants between the age of 50 and 71 (Sitha et al., 2009). The study looked at red and processed meat consumption and its relationship to total mortality. The total risk of dying within the upcoming 10 years was 31 percent on average for the participants in this research. Findings showed that the chances of dying within the upcoming 10 years were 16 percent higher for the male participants with the highest meat intake in comparison to the male participants with the lowest intake. It is interesting to look at the different impacts of processed and unprocessed meat. A European study including almost 450 thousand participants from 10 different countries showed that increased consumption of red meat (160 grams vs. 10-19 grams a day) relates to a 14 percent increase in total mortality (Rohrmann et al., 2013). The same study investigated a similar pattern for processed meat intake and found that the intake of processed meat was associated with an even more significant 44 percent increase in mortality. A meta-analysis of studies also showed that the intake of 50 grams of processed meat per day is associated with a 42 percent increased risk of coronary heart disease (Micha, Wallace & Mozaffarian, 2010).

Food Security

Animal farming is in itself an intensive process, in the sense that most forms require a high input compared to the output (Poore & Nemecek, 2018). Animal farming and intensive animal farming hereby form a serious concern for global food security. Figure 5 shows the land use per product needed to produce 1000 kilocalories worth of product. The highest land use is for beef herds, needing 119.49 square metres to produce 1000 kilocalories. When comparing this to maize (0.65M2), rice (0.76M2), root vegetables (0.89M2) and potatoes (1.2M2), the production of beef needs roughly 100-200 times more land. Beef herd and lamb are rather extreme in their land use compared to other animal products. Cheese uses 22.68, pig meat 7.26 and eggs respectively 4.35 square metres for 1000 kilocalories, which is still significantly higher compared to the plant-based options, as visible in *Figure 5*. Kilocalories are possibly not a complete indicator of food efficiency, as calories reflect on energy and not on other nutritional purposes. Meat is often praised for its high amount of protein, but even when comparing beef and lamb to protein-rich alternatives such as tofu or peas, the plant-based alternative seems to be significantly more land-use efficient (Ritchie, 2021b). On one square metre of land dedicated to the production of tofu, a 100 square metre dedicated to beef is needed to produce the same amount of proteins. The nutritional inefficiency of meat products is logical considering the fact that farm animals are being fed with some of the plant-based alternatives the products are being compared to in Figure 4. Very little of the input (animal feed) will contribute to the end product (animal product), considering the high amount of waste produced throughout the life of the animal. A lot of energy in animal feed is used by the animal to live and perform regular daily activities and will therefore not be part of the end product. The feed Conversion Ratio describes the ratio between the mass of human-edible output and the mass of human-edible input (Ertl et al., 2015).

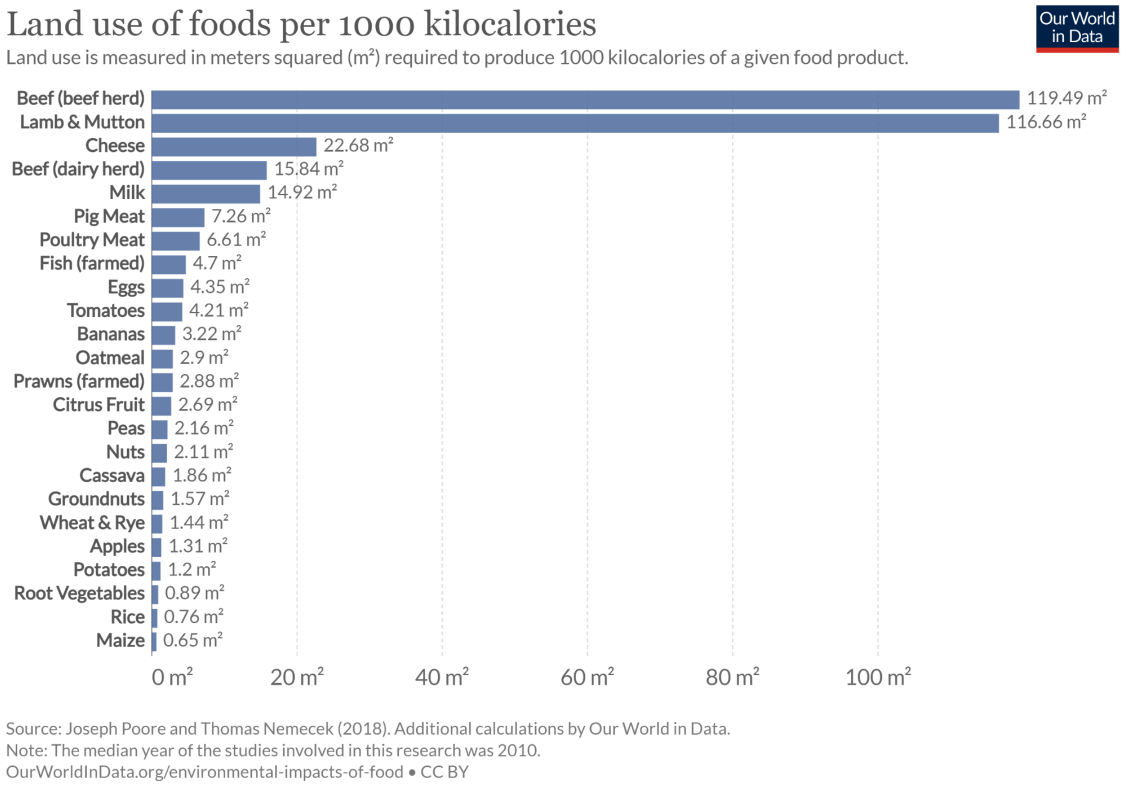

Figure 5: Land use necessary to produce 1000 kilocalories, divided per product (Poore & Nemecek, 2018).

Discussion

The importance of interventions using co-benefits seems relevant when considering the number of different topics already related to intensive animal farming. Often crises are addressed from a singular angle and discipline, focusing on the obvious challenge or problem presented by the crisis. A co-benefit perspective has the potential to create a more sustainable solution. In a capitalist society, the focus is on personal profit or benefit, complicating societal shifts and crisis management. Capitalist society tends to prioritise financial benefits over social benefits, implicating the implementation of a co-benefit approach. The climate crisis is the perfect example of the difficult relationship between crisis management and capitalist society (Guerrero, 2018). A co-beneficial approach focuses on benefits, but instead of focusing on personal benefits, it aims to create a web of benefits connecting to the same intervention. The overall benefit of all interconnected benefits should outweigh the benefit gained from an intervention focussing on a singular outcome. A co-benefit approach needs the merging of different fields and people towards a common interest, such as the promotion of global health. It should be questioned whether the application of a co-benefit approach is realistic, also considering the lack of common interest in a polarising capitalistic society.

The paper shows that intensive animal farming relates to a variety of topics and is impacting the current polycrisis. Literature showed the involvement of intensive animal farming in the current climate crisis, which is associated with serious health risks. The high quantity of farmed animals related to the intensifying of farming (allowing high rates of consumption) is partly responsible for the significant climate impact of the industry. Poor wastewater management in intensive farming relates to eutrophication and contamination of aquatic environments. Next to human-animal interaction and atmospheric pollution, wastewater facilitates a medium between human society and intensively farmed animals. Both hormones and nutrients deriving from intensive animal farming disrupt the aquatic ecosystem. The disruption of ecosystems endangers human excess to ecosystem services, on which we are highly reliant. Research showed the possible health risk of the consumption of hormone-containing meat, animal products or other products deriving from a contaminated ecosystem (such as polluted drinking water). Different sources and organisations give different risk indications of the variety of hormones used. Many of the health risks still seem unsure or are still being debated. The high animal density and low animal welfare conditions associated with intensive animal farming also create a need for (preventative) antibiotic use on animals. The high use of antibiotics causes an increase in antibiotic-resistant bacteria. The poor treatment of wastewater, direct human-animal contact and the consumption of meat products facilitate the transmission towards human society. High animal density and low genetic diversity make intensively farmed animals an amplifier and intermediate host of zoonoses, increasing the risk of future pandemics. Another health risk is posed by the consumption of meat. Processed meat, often derived from cheap and intensively farmed production, is responsible for health implications and diseases increasing total mortality (Richards & Richards, 2011). The poor feed conversion ratio of animal products complicates the already existing problem concerning food security. Global access to a sufficient amount of nutritious food is needed to obtain global health and it can be argued that inefficient production forms relating to nutrition sustain the lack of access to nutrition. The co-benefits of reducing intensive animal farming from an environmental and human health perspective include; Limiting human-induced climate change, promoting healthy (water- and soil-dependent) ecosystems, sustaining our interdependent relationship with the ecosystem and its services, increasing animal welfare, limiting health risks caused by exposure to antibiotics, antibiotic-resistant bacteria and (synthetic) hormones, limiting the risk of new emerging zoonoses, suggesting a healthy nutritional shift limiting health risks associated with diet and limiting food insecurity.

The paper shows various aspects specifically associated with intensive animal farming (f.e. the use of externally produced feed, antibiotic use and a high quantity of animals). The different practices related to intensive animal farming all seem to be related to the aim of efficiency. The definition of intensive animal farming given in the introduction correctly describes one of the elements of intensive animal farming, as its independence of own farmland and feed production is a common characteristic, but it could be argued that the definition should reflect upon an ideology rather than a specific practice relating to this ideology. Building an industry fitting to the capitalistic system creates a common ideology surrounding the efficiency of production, aiming for economic profit. The aim for economic profit seems to be at the expense of planetary health. It is difficult to define a practice by its ideology and therefore it makes sense that the definition is defined by practices. As most animal products are produced to compete in our financial profit-based society, all production forms include some form of efficiency focussed on profit. Maybe it does not make sense to define intensive and not intensive, but rather to define different degrees of intensity of animal farming. The paper does not include co-benefits relating to economic growth. It is unsure whether economic growth combines well with pursuing co-benefits for environmental and human health. Both green growth and degrowth are proposed solutions to stop environmental degradation (Sandberg et al., 2019). Green growth suggests the possibility for environmentally sustainable economic growth and degrowth suggests the degrowth of our economy in order to sustain or gain environmental sustainability. Even though green growth is still more widely accepted than degrowth, degrowth shows stronger normative justification (Sandberg et al., 2019). It might be important to rethink our constant aim for economic growth and the “efficiency” related to this.

Intensive animal farming seems to prioritise efficiency over animal welfare. As discussed in the main section of this paper, the aimed efficiency is accomplished through high animal density, the use of hormones and antibiotics and the use of external food sources. The review by Albernaz-Gonçalves et al. (2022) discusses different aspects of intensive pig farming and how it affects the welfare of pigs. Pigs kept in a crowded environment with poor micro-climatic conditions and stressful weaning methods were found to have weaker bodies, a poor immune system and redirected behaviour. These consequences make the individuals more vulnerable to infections and pathogens, explaining “the need” for antibiotic use. This need for antibiotic use in intensive animal farming should trigger us to rethink our practices. While the research question discusses the reduction of animal farming, the paper also aims to reflect upon the question of whether we need to rethink our relationship with the other animals in our ecosystem. The intensification of animal farming connects to the way we treat animals and is directly related to human health. Animals are being treated as a product, aimed at product efficiency. It is difficult to properly define animal welfare as it implies valuing subjective measures and judgements considering the feelings and cognitive abilities of animals and the importance of these (Dawkins, 2021). The main focus of animal welfare relates to both the needs of the animals (in terms of what they would want themselves as sentient being) and their physical health. Our still relatively limited knowledge of the cognitive processes of non-humans makes it difficult to accurately provide a definition of animal welfare. Whereas a comprehensive definition of animal welfare is rather difficult to provide, the aim of animal welfare can be clearly defined. Both the desires of the animal and their health link to the welfare of the animal. Both aspects are crucial as they do not always complement each other. The individual desires of the animal are not always beneficial to the health of the animal. Consider a situation in which an animal would have unlimited resources, leading to overconsumption and related health effects. Concepts often related to animal welfare are the absence of pain and injury and the maximisation of pleasure and happiness (Fraser, 2008). The affective states of an animal might be the most complete and accurate way, to sum up the welfare-related experiences of the animal. Affective states describe the pleasant or unpleasant emotions and other feelings experienced by the animals (Frazer, 2008). When talking about a sensitive topic such as animal welfare or the treatment of animals many are quick to point out who they deem responsible. The arrogance of Western society often associates the emergence of zoonoses with the “unhygienic animal markets” in non-western countries. It is often related to the consumption of “weird” animal products or anything unrelated to the non-western forms of animal production and consumption. The COVID-19 pandemic, which is expected to have started in Wuhan, China, showed how racism was triggered by the othering of people based on the unfair connection made between one's Chinese nationality and their responsibility for COVID-19 (Devakumar et al., 2020).

The suggested reduction of intensive animal farming would lead to less meat production and the production of relatively more high-quality meat. Logically this will increase the price of meat, as less intensive forms of animal farming are higher in cost and a lowered production would raise the price. Meat would likely become more of a luxury product again, possibly excluding the lower socioeconomic class. A decrease in meat production aims to reduce overall meat consumption, not to exclude certain parts of society while remaining the usual nutritional patterns for the wealthier part of the population. It is also important to consider the social complexity of advocating for reduced forms of intensive animal production. Often people give a defensive response towards the promotion of plant-based diets or towards the advocating of limiting our meat consumption (Hinrichs et al., 2022). Research by Hinrichs et al. (2022) showed that mainly men tend to give a defensive response. Various articles have written about meat consumption relating to one's feeling of masculinity and that current gender roles create the expectation that men should eat meat in order to feel "manly" (Adams, 2015) (Rosenfield & Tomiyama, 2021). Even though these gender roles can be considered problematic, it might be important to consider the sensitivity of the topic. The consumption of meat and other animal products is for many a highly valued practice, close to the emotions of the individual. The perception of one's identity is connected to the practice, explaining the negative effect experienced (experience of negative emotions) by the individual when this practice is being challenged.

Conclusion

Reducing intensive animal farming is related to a wide range of co-benefits promoting both environmental and human health on a global and local scale. Limiting human-induced climate change, promoting healthy (water- and soil-dependent) ecosystems, sustaining our interdependent relationship with the ecosystem and its services, increasing animal welfare, limiting health risks caused by exposure to antibiotics, antibiotic-resistant bacteria and (synthetic) hormones, limiting the risk of new emerging zoonoses, suggesting a healthy nutritional shift limiting health risks associated to diet and limiting food insecurity are all co-benefits relating to the reducing of intensive animal farming. Economical outcomes are not taken into consideration in the paper and might not be benefitting from a reduction in intensive animal farming. For further research it might be interesting to consider the economic aspect; investigating whether co-benefits for environmental and human health limit economic growth. The urgency of the current poly-crisis might require thinking beyond the profit-based society and thus beyond economic benefits. There is a need for collective goal-setting for those interested in planetary health. Using a co-benefit approach, policymakers can gain access to a more inclusive perception of the implementation of policies, increasing overall societal and environmental benefits. Intensive animal farming, representing the efficiency-based society, might need rethinking in order to obtain co-benefits and achieve planetary health.

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