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Both downsizing and improvements to livestock systems are needed to stay within planetary boundaries

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A focus on improvements to livestock production limits the scope for food systems transformation. Research, policy and industry must adopt measures to downsize livestock production and consumption to meet sustainability targets and facilitate a just transition.

Transforming current food systems to fit within the planetary boundaries while producing enough safe and nutritious food for all is urgent. Whether one looks at climate change, biodiversity loss, malnutrition, systemic inequalities or geopolitical instabilities, major changes in the food systems are critical. Research in agricultural and food sciences has responded to such challenges with substantial advances[1]. Yet, the focus on improving production alone and increasing efficiency may act to 'lock-in' the system to a fundamentally unsustainable state. For example, by improving output efficiency of highly specialized farming systems, such specialization is normalized, exacerbating multiple environmental and social impacts, such as the generation of nutrient surpluses on livestock farms. Many benefits of increasing efficiency at the production level are also being offset by increasing consumption and net resource use and results in what is known as a rebound effect. Livestock production has certainly followed this route, with substantial gains in productivity and efficiency, in parallel with increased consumption following urbanization and increased affluence. This contributes to nutrition transition with excessive quantities of some types of food, also of animal origin, that exacerbate obesity and non-communicable diseases[2].

Extensive research, employing a variety of methods and assumptions, has demonstrated that decreasing livestock production, rather than merely improving it, is crucial for achieving sustainability[1,3]. Confronted with such evidence, researchers working on improving animal husbandry (for example, in animal and food science) and stakeholder groups dependent on livestock production (for example, meat companies and livestock farmers) are understandably concerned about the future of livestock. Many working in or connected to the commercial livestock sector challenge the need to reduce livestock production with statements such as 'it's not the cow but the how', suggesting that the problem is only with how livestock is produced, rather than the number of livestock. The Dublin Declaration (2023) and related publications[4] are recent examples expressing such views. In an informed and balanced discussion on the future role of livestock, it must be acknowledged that when improvements in current production practices are not sufficient to meet sustainability targets, downsizing (or downscaling[3]) animal agriculture must also be considered. The principles of just transition[5] need to ensure that the food system can deliver safe and nutritious foods to all while safeguarding other societal goals (Fig. 1). Evidence supporting the need to make improvements in animal production while simultaneously downsizing production and consumption globally is convincing from key perspectives.

Healthy nutrition

The raison d'être of the food system is to provide humanity with adequate amounts of nutritious food. Despite massively increased production and consumption of animal-source foods and globally sufficient protein supply during the past decades, some 40% of the world's population experiences malnourishment of various forms, and the problem is projected to persist[2]. Substantial evidence exists that adequate protein and micronutrient intake can and should originate from a variety of predominantly plant sources and smaller amounts of animal-source foods. Such foods also include fish and seafood with aquaculture being a viable alternative to terrestrial livestock in suitable regions. Recent randomized control trials demonstrated that reducing red and processed meat consumption to a third of that in a typical Western diet would provide the adequate intake of essential amino acids to healthy adults[6]. Hence, there is scope in food systems transformation for diversification of protein intake, and for geographic redistribution of animal-source foods. Such transformation would entail downsizing to a sufficient intake through better alignment to dietary guidelines in high- and middle-income countries or among affluent groups, enabling increased consumption of animal-source foods by food insecure and vulnerable populations lacking access to alternatives.

Planetary boundaries

The central premise of sustainable food systems is that the human right to nutritious food is inseparable from the need to safeguard the environmental resources essential for food production now and into the future. Rigorous research in quantifying how the right to nutritious food for all can be achieved on regional, continental or planetary scales concludes that shifting to predominantly plant-based diets is not just desirable, but essential[3,7]. Though vastly variable, livestock production generally exerts disproportionate negative effects on climate change, biodiversity, habitable land use and water use in relation to

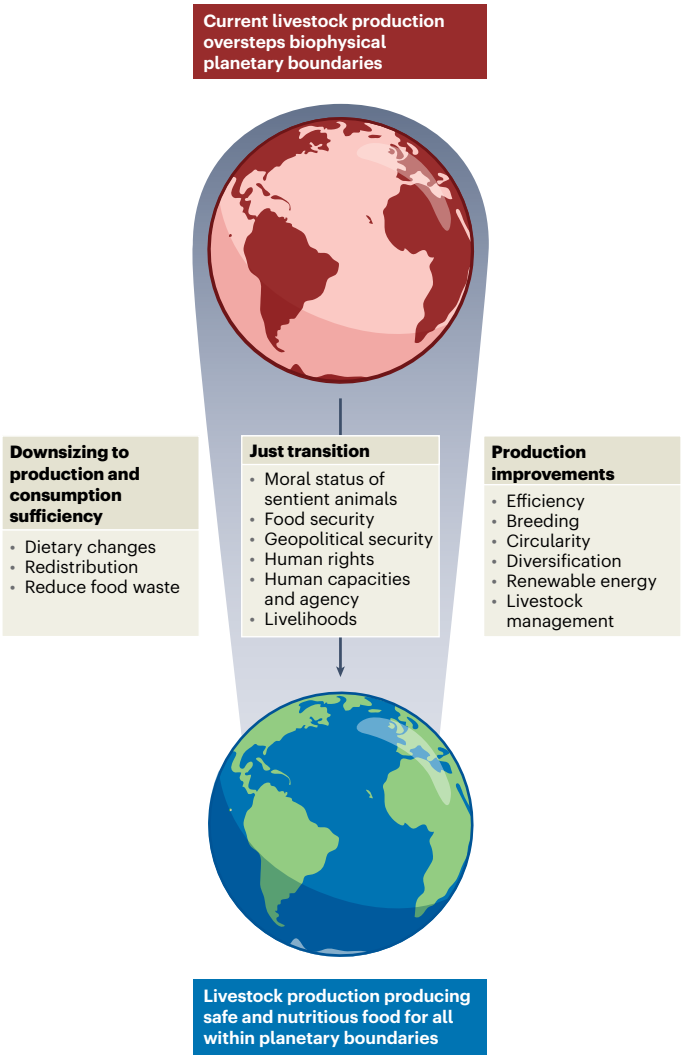

Fig. 1 | Livestock contributes to sustainable food systems in reaching its goals of providing safe and nutritious food only if its production fits within biophysical planetary boundaries. The sustainability of livestock production is enhanced through improvements in production, but sustainable food systems also require downsizing of livestock production and consumption, and a broader food system transformation. The transition to sustainable livestock production systems should be pursued in accordance with the principles of a just transition, considering societal impacts and negotiating among stakeholders.

its contribution to human diets. Traditional pasture-based ruminant production can maintain pastoral biodiversity, promote carbon sequestration and support the nutrition security and incomes of particular groups in food insecure regions, but it claims considerable land, has a high emission intensity per unit of output and may have high carbon opportunity costs. Critically, the potential of such systems at scale to meet the global demand for meat and dairy is limited, albeit with considerable regional variation[8].

Numerous advancements have been made to improve livestock systems to boost resource-use efficiency and minimize environmental impacts through management and breeding (for example, increased productivity of breeds, shifts to monogastric animal systems, improved forage yields, use of feed additives, renewable energy and methane digesters). Many of these, however, compromise animal welfare and biodiversity conservation, or create food–feed competition, shifting them away from traditional and multifunctional systems. Increasing circularity and limiting animal feeding to resources that cannot be eaten by humans directly (forage, byproducts and waste) minimizes food–feed competition and environmental impacts. Yet, the scale of implementation is limited by the available quantities of such resources and is considerably lower than current consumption levels in high- and middle-income countries[9]. Similarly, livestock production based on agroecological principles scaled up to all of Europe would not maintain the current exports for global diets unless the consumption of animal products in Europe is lowered[10]. Impactful production improvements that deliver additional services, such as biodiversity conservation and improved animal welfare, are only possible at large scale in combination with downsizing total intake of animal foods. Downsizing enables improved production both in traditional multifunctional systems and intensive resource-efficient ones.

Social role of livestock

The role of livestock — a "millennial-long-proven method to create healthy nutrition and secure livelihoods"[4] — has been considerable. Substantial and varied social values of livestock, particularly in traditional agrarian systems, were developed during times of low population densities and in rural societies. With a world population approaching 10 billion and with limited agricultural land and other resources, such systems cannot sustain the consumption levels typical of the high- and middle-income countries. Many traditional livestock cultures are predominant in regions with already precarious environmental conditions and are threatened by climate change, exacerbated by the upkeep of large numbers of livestock. The overall social benefits of all livestock systems are also undermined by substantial external costs, including risk of zoonotic diseases and drug-resistant pathogens[11]. Most importantly, social processes that define human cultures, including dietary practices, and economic systems can adapt to the changing conditions, whereas the biophysical laws that define the planetary boundaries are non-negotiable. Development of new forms of livelihoods and production methods with re-evaluated and reinvented social roles for animals is at the heart of just transition.

Alternative food production systems

Plant-centred farming systems are equally valid "millennial-long-proven methods to create healthy nutrition and secure livelihoods" and deserve boosted investments into production improvements. In some regions, they need to be reconnected with livestock. New technologies to meet the growing demand for proteins also include meat and dairy analogues based on plants, fungi, and microbial or animal cells. They also have the potential to be disruptive to present systems, thus posing challenges for adaptation and power dynamics. Animal domestication is a prime example of a formerly novel technology that has profoundly impacted human societies both positively and negatively. Currently, an overwhelming proportion of the financial and technical capital, know-how and capacities in modern agriculture revolve around livestock production, which attracts 1,200 and 800 times more public funding than is channelled to novel food technologies in the EU and USA, respectively[12]. Just transition requires that future food systems avoid replicating the existing political economy inherent in highly centralized livestock production and aim for improved nutrition and food security, including for people with deficient diets. This underlines

the responsibilities of public policies in safeguarding fair opportunity for differently sized actors to engage in innovation and development of both high- and low-tech solutions[5].

Ethics

The moral status of sentient animals (beings capable of experiencing feelings and suffering) is highlighted by global ethics and justice philosophers, and is legally recognized in most regions. Understanding of the sentience of some non-human categories, such as fish, is in progress. Some goods and values are non-negotiable, which means that they are so important that they should not be overridden unless they conflict with other equally non-negotiable goods. Minimum conditions for justice commonly take basic needs, including health and adequate nutrition, as non-negotiable[13]. Moral philosophy also widely endorses that non-human animals, too, have entitlements or primary interests that cannot be overridden by secondary, less vital interests of humans[13]. Planetary boundaries invoke other non-negotiable interests: crossing them would risk the safe existence and development of humans and the existence of non-human animals. Downsizing livestock use to a quantity that does not exceed the levels necessary for the healthy nutrition of humans is thus also about moving towards more ethical and just societies[5].

Research integrated into solutions

Sustainability transformations should be monitored to compare transition scenarios at relevant scales. Greenhouse gas-related metrics dominate sustainability assessments due to the unparalleled challenges of preventing the breakdown of the climate with the associated socio-economic costs. In any sector, targeting high-emission products and activities consumed or performed above their contribution to wellbeing is a clear priority for downsizing. Though more comprehensive approaches to assessing impacts beyond climate are needed and constantly being developed and tested, substantial evidence already indicates that downsizing global livestock production may also deliver on minimizing nutrient losses and zoonotic diseases, biodiversity loss in non-agricultural ecosystems, and improving human health[2,7]. Solutions that improve production (that is, minimizing emissions, preventing negative land-use changes and increasing soil carbon) and downsizing on animal foods, while diversifying diets, are both essential and complementary[3]. Importantly, context-specific solutions should also contribute to global human welfare: the high production output of animal foods in some regions should be channelled towards meeting dietary needs in more resource-strained regions instead of into high domestic consumption[14].

A just transition

To be socially acceptable, the transition to sustainable food systems needs to appropriately consider distributional (how various benefits and harms are distributed between actors) and representational (who can have a say in decision-making about the transition process) justice[5,14]. The priority has to be on food security and the right to nutritious food for all while respecting planetary boundaries, delineating the space, in which businesses should operate for an economically resilient food system. With the objective of bringing livestock production within the planetary boundaries, just transition needs to provide alternative employment in rural areas, involving and empowering those affected, protect human rights, maintain geopolitical security, consider the moral status of sentient animals, and support human capacities and agency[5]. Politically negotiating and implementing just transitions will certainly pose challenges, but overcoming them requires honesty on two issues: the reasons for change (the future of human societies and non-human animals) and the magnitude and speed of change required to bring humanity's operating space safely within planetary boundaries[15]. The necessity for both efficiency and degrowth perspectives must be acknowledged and integrated into the transition to sustainable food systems[3].

Although important work on the best options for improving livestock production continues, quantitative feasibility assessments are arriving at a consensus on the necessity of downsizing livestock production globally and animal-source food consumption in affluent countries and population segments. To maintain credibility, science and decision making need to rely on data measuring such feasibility against the available resources, rather than heed reassurances on the potential of continuous production-side improvements. The well-intentioned 'it's not the cow but the how' becomes wishful thinking when confronted with solid evidence, which leads us to conclude that 'it's the cow and the how'.

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