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Acknowledging ecological debt: towards just, humane and sustainable food systems in Africa

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This review interrogates the historical and ongoing consequences of the Global North's industrialization trajectory on the Global South, including the industrial agriculture systems subsequently exported to the Global South. These caused significant ecological harms including major impacts on the "triple planetary crisis" of climate change, pollution and biodiversity loss – which were disproportionately caused by the Global North and disproportionately affected the Global South; and other detrimental impacts on human and animal well-being. Africa has been used as a focus for examining these issues, revealing additional harms to traditional African livestock practices and cultural values such as Ubuntu and Ukama, which emphasize interconnectedness and respect for all living beings (and accord with One Health principles). This paper considers the concept of ecological debt in this context, underscoring the moral and financial responsibility of industrialized nations to provide "restorative justice" for these multiple harms, and proposing that this should be used to support just transition toward humane, sustainable and culturally-appropriate food systems in Africa. A 3Rs framework - Reduction, Refinement, and Replacement - is proposed to guide this transition. Reduction includes addressing food waste and rebalancing diets toward plant-based options. Refinement emphasizes regenerative agriculture, animal welfare, and traditional knowledge. Replacement promotes healthy, nutritious alternatives, including indigenous superfoods, plant-based, and cultivated products. However, food systems change is complex, and barriers to change remain – particularly as regards policy, funding, quantifying and securing ecological debt, and dietary change – all of which could benefit from values-based governance, and holistic reform based on further specialist research.

KEYWORDS

food systems, industrial agriculture, livestock, ecological debt, environment, animal welfare, sustainable development

1 Introduction

Industrial agriculture was introduced in the Global North with the aim of ending food shortages after the Second World War – first through the "Green Revolution" (John and Babu, 2021) and then its successor the "Livestock Revolution" (Delgado et al., 2001). A 2017 Report on The Global Food System: An Analysis (Gladek et al., 2017) acknowledges that the system has been widely credited with helping to avert "large-scale food shortages in the post-WWII era." However, industrial agriculture introduced intensive practices which drove ecological degradation and other unsustainable practices.

Once introduced, industrial practices came to dominate the food system in the Global North, and a small number of actors in the fields of production, processing and retail now control most of the industry and strongly influence policy making (Clapp et al., 2025). This supports the continued subsidization of industrial agriculture from governments, despite government pledges to remove such "perverse subsidies" (Bellman, 2019) and lack of progress in ensuring that food industries take responsibility for the detrimental impacts of their businesses ("internalizing externalities") (Coinon et al., 2023). This support, coupled with the economies of scale of large corporations, placed local small-scale producers at a competitive disadvantage, impacting jobs and livelihoods.

Large multinational corporations involved in industrial food systems, supported by their governments, export the technology and inputs necessary to implement the model in the Global South; and in some cases, they own and operate production sites across multiple continents (including in Lower- and Middle- Income Countries (LMICs). Even in cases where the industrial model arises without external influence from multinational corporations, its adoption in LMICs can create dependencies on resources that must be imported (e.g., feed, fuel, drugs, and equipment) and therefore vested interests in its continuance (Lam et al., 2019).

With regard to the Livestock Revolution, this introduced highly mechanized industrial systems to boost a narrow concept of productivity, with animals raised in close-confinement, which causes a myriad of animal welfare problems (Nordquist et al., 2017). These intensive conditions also separated livestock from their food sources, leading to an expansion of land use for growing monoculture crops for animal feed, increased transport – feed and food miles - and animal manure becoming problematic waste, instead of being used in rotational farming techniques to replenish the soil. Industrial agriculture is now one of the main causes of deforestation, land degradation, climate change and biodiversity loss; and industrial animal agriculture is the leading cause of pollution (Ritchie et al., 2022).

Major UN institutions now reference "the triple planetary crisis" which refers to the three main interlinked environmental issues that humanity currently faces: climate change, pollution and biodiversity loss. These are existential and cascading crises, which need to be resolved if we are to have a viable future on this planet (United Nations Climate Change, a; Passarelli et al., 2021a; Richardson et al., 2023). They are largely driven by the Global North, yet the Global South bears the brunt of their impacts (Climate Change Performance Index, 2025).

The detrimental impacts of industrial agriculture have been known for many years, but the political will has not been present to successfully address the complex food system dilemma until very recently. A key problem has been that food has been dealt with in research and policy silos. This silo management [which the famous environmentalist and quantum physicist Vandana Shiva called "monocultures of the mind" (Shiva, 1993)] measured success in terms of short-term food productivity and contribution to Gross Domestic Product (GDP), without consideration for the complex interlinked – or "nexus" - issues of food systems.

However, the need to take a more holistic approach to food systems which takes account of interlinked issues is now supported by high-level policy-makers and research: including in the Global Environment Outlook (GEO) of the United Nations Environment Programme (UNEP) (UNEP, a), by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (IPBES), and through the development of the One Health policy stream (WHO, a). This has led to acceptance of the need for transformation towards just, humane and sustainable food systems which address the interconnected challenges of human, animal, and environmental well-being; but there remain barriers to practical and effective policy change. This review has identified academic and policy contributions and analysis on these issues, considered what is needed for food systems change, and from this identified and examined major barriers to progress.

2 Ecological debt

Ecological debt (Warlenius et al., 2015) is a concept built upon a foundation that draws on biophysical accounting systems, ecological economics, environmental justice and human rights, historical injustices and restitution. It underscores the moral and financial responsibility of industrialized nations to provide "restorative justice" (European Forum for Restorative Justice) to address the environmental harm caused by both their own rapid industrial development trajectory, and their historical and ongoing exploitation of the Global South (including the consequences of colonization and neocolonialism).

The important role of food systems is often forgotten in the context of ecological debt. However, the early industrialization of food systems in the Global North has made an immense contribution to environmental harms including global climate change; and their role in promoting industrial livestock systems in Africa has greatly exacerbated the continent's multiple environmental issues (Richie et al., 2022).

The prosperity of the Global North was built upon a system which did not factor in "externalities" such as environmental harms (Inegbedion, 2024). Yet we share one planet, with a common environment, so the action of one nation or region affects others. The Global North has been responsible for the "lion's share" of the harm to the environment, including the triple planetary crisis (for example, 92% of excess global CO_2 emissions) (Hickel, 2020), but the Global South - less economically and technically equipped to

cope - has suffered disproportionate impacts which are harming food security, ecosystems and economies (World Meteorological Organisation, 2023; International Institute for IIED, 2024).

The ecological debt owed by the Global North has thus far been primarily addressed in relation to climate change, with the 2022 Climate Summit or "Conference of the Parties" (COP) agreement to provide "loss and damage" funding for vulnerable countries hit hard by floods, droughts and other climate disasters, which was finalized at the 2024 COP (United Nations Climate Change, b; United Nations Climate Change, 2024). Developed countries were urged to fulfil their small commitment to provide $100 billion annually and to double adaptation finance, while multilateral development banks were called upon to leverage private financing.

However, ecological debt also includes the non-economic or intangible dimensions of loss. These include loss of life, biodiversity, and the erosion of indigenous and local knowledge systems (Carstens and Preiser, 2024) – including traditional agricultural practices and cultural values (Pearson et al., 2021) - and the economic marginalization caused by exploitative trading models and the imposition of foreign technologies and genetics (FAO, 2015; FAO, 2016a).

This paper argues that the Global North has a moral obligation to provide restorative justice in the form of ecological debt, and that part of this should be used to invest in Africa's "just transition" towards humane and sustainable food systems. This transformation should be fully aligned with One Health principles - which are essential for addressing the interconnected challenges of environmental degradation, animal welfare, and human well-being - and with African cultural values such as Ubuntu (Khomba, 2011) and Ukama (Carstens and Preiser, 2024).

3 Ecological impacts of industrial animal agriculture

The detrimental impacts of industrial animal agriculture have been known for many years. For example, the FAO published a seminal report (by Henning Steinfeld et al., 2006) called "Livestock's Long Shadow" (Steinfeld et al., 2006) which concluded that the environmental toll of industrial livestock farming is massive; and that the sector is a major driver of deforestation, land use change, water pollution, and climate change.

Since the "Livestock Long Shadow" report, political awareness has increased about the serious and urgent state of our environment. Major UN institutions now reference "the triple planetary crisis" of climate change, pollution and biodiversity loss; and the scientific community has collectively sounded the alarm on the rapid degradation of planetary resources, manifest ecological overload, as well as the erosion of the ecological foundations of our economies (Stockholm Resilience Centre; Passarelli et al., 2021b; United Nations Climate Change, 2022). The significant contribution of industrial food systems to each and every one of these existential crises has now been recognized (IPBES. McElwee et al., 2024).

Also relevant is the recognition by the UN General Assembly on 28 July 2022 of the human right to a clean, healthy, and sustainable environment, which introduced an international legal norm (UNEP, 2022; Mwanza, 2023).

It is worth noting that water is an also existential issue for Africa, with the World Health Organization (WHO)'s African Region reporting that water scarcity affects one in three people in the region (World Health Organization African Region). Nearly one-third of the total water footprint of agriculture in the world is related to livestock production, with blue and grey water footprints of animal products the largest for industrial systems (Mekonnen and Hoekstra, 2012).

3.1 Climate change

With regard to climate change, the UN's Food and Agricultural Organization (FAO) has said that the global food system as a whole (farming, transportation, packing, etc.) contributes 20 to 30 percent of anthropogenic greenhouse gas (GHG) emissions (FAO, 2024) and are the leading cause of deforestation, which further exacerbates climate change. FAO has released various estimates on the contribution of livestock to global GHG emissions, ranging from 18% (2006) down to 12% (FAO, 2023a); with 14.5% (2013, 2017) being the most widely reported (Gerber et al., 2013; FAO, 2017). However, other studies have examined FAO's methodology and suggest that the figure may be higher; and Twine (2021) recommended updating this to at least 16.5% (Twine, 2021).

The effects of climate change are already placing an additional burden on agricultural productivity (Yang et al., 2024) and food security, with unpredictable and erratic weather systems including prolonged droughts and floods. These impacts are expected to deepen, with least-developed countries often most affected (FAO, 2021a).

Despite the pivotal role of food systems in climate change, COP discussions revealed their exclusion from many countries' Nationally Determined Contributions (NDCs). This underlines the need for countries, including African countries, to include transformation to humane and sustainable food systems within their national development and climate action plans (Badiane et al., 2023).

3.2 Pollution

Intensive livestock operations and the crops that supply these generate large quantities of animal wastes, excess nutrients including phosphorus and nitrogen, and antibiotic residues. These industrial systems contribute significantly to environmental pollution, posing substantial challenges to water, air and soil quality (Williams, 2024). Excess nutrients from farm run-off also pollute marine environments causing eutrophication and "dead zones" in the ocean (Bon; National Ocean Service).

3.3 Biodiversity loss

The UNEP/International Resource Panel has stated that food systems are responsible for 60% of global terrestrial biodiversity loss (UNEP/International Resource Panel).

Industrial agriculture is one of the main causes of land degradation and biodiversity loss. Intensive monocultures – including livestock and crops for animal feed - deplete soil and leave it vulnerable to erosion and also detrimentally impact biodiversity leading to declining populations of birds, insects and other pollinators (OECD; Belete and Yadete, 2023).

Biodiversity plays a fundamental role in enhancing agricultural resilience and sustaining food production. This resilience is essential for mitigating the impacts of climate change, pests, diseases and resource scarcity which pose significant threats to global food security (Christianah and Folarin, 2024).

The 2021 Chatham House research paper on "Food system impacts on biodiversity loss", supported by UNEP (Chatham House, 2021) stated: "Cheap food is driving destruction of the natural world."

Industrial livestock systems rely on exotic breeds selected for high productivity, first introduced to Africa by colonial settlers. This has reduced genetic diversity and undermined local adaptability. While indigenous breeds still dominate traditional systems in East and Southern Africa, many native breeds face extinction. The less ecologically fit exotic animals are more vulnerable to disease - including zoonoses - driving up antimicrobial use and contributing to antimicrobial resistance (AMR), posing major veterinary public health risks.

Livestock diversity facilitates the adaptation of production systems to future challenges and is a source of resilience in the face of greater climatic challenges (FAO, 2016b). In the words of FAO's former Director-General, José Graziano da Silva:

"Genetic diversity is a mainstay of resilience and a prerequisite for adaptation in the face of future challenges." (FAO, 2015)

4 Other detrimental impacts of industrial animal agriculture

The UN Committee on World Food Security report, "Sustainable agricultural development for food security and nutrition: what roles for livestock" (FAO, 2016c) and other recent flagship reports have recognized that – in addition to environmental impacts - intensive livestock production contributes to negative impacts on human health (including through antimicrobial resistance, emerging diseases and non-communicable diseases), social structures (through rural abandonment, poor working conditions and low wages) and animal welfare.

4.1 Food security, poverty, jobs and justice

The world's smallholder farmers produce around a third of the world's food (FAO, 2021b). Mostly these small-scale farming systems are the primary source of food for the population in developing countries (Agricultural Research Development Program (ARDP), 2023) and a primary livelihood for millions of households worldwide. The UN Commission on Sustainable Development (CSD) and other major international organizations now recognize the significance of smallholder farmers in ensuring food security and a global sufficient supply of food (Denison et al., 2016; Kapari et al., 2023).

In many countries, local smallholder farmers, peasants and pastoralists face numerous challenges and have been unable to compete with industrial production systems, which are highly subsidized and benefit from "economies of scale" (Foodprint; Dhillon and Moncur, 2023).

The roll-out of industrial systems will often not enhance food security for local populations over the long-term, with any perceived short-term gains unlikely to be sustainable in the face of ongoing detrimental impacts, and - most importantly - future existential environmental disruptions.

As regards trade, Africa's supply chains are linked to, and influenced by, its former colonizers. Restrictive trade policies from wealthy, western countries and blocs keep African countries chained to raw materials exports while hampering efforts to move up the manufacturing value chain [Catholic Agency for Overseas Development (CAFOD)]. Moreover, lopsided EU and USA trade agreements see African countries flooded with cheap, subsidized goods while able to export little in return (Gonzalez, 2004a; Rwabwogo, 2022). In addition to unfair trade agreements and tariff barriers, non-tariff barriers are a problem, as are non-tariff barriers, including unwieldy documentation and border compliance (Bonuedi et al., 2020).

The recent establishment of the African Continental Free Trade Area (AfCFTA) promises some hope in providing African nations for the first time a platform to trade as a bloc and speak with one voice. AfCFTA will create the largest single market in the world in terms of the number of countries and people (Fusacchia et al., 2022).

4.2 Animal welfare

There has been an ancient moral belief – shared by indigenous people across the world - valuing the interconnected relationship between humans and the natural world, promoting proper and considered human conduct towards other species. More recently, as our knowledge of animals and their sentience has increased, concern about their welfare in intensive animal production systems has burgeoned to become a pressing ethical issue (Proctor et al., 2013).

There is an international policy stream, governed by the World Organisation for Animal Health (WOAH), an international organization which has 183 member countries (WOAH, a) including 54 African countries (WOAH, b). These members have agreed a Global Animal Welfare Strategy (WOAH, c) with a very pertinent vision:

"A world where the welfare of animals is respected, promoted and advanced, in ways that complement the pursuit of animal health, human well-being, socioeconomic development and environmental sustainability".

WOAH has also developed internationally-accepted animal welfare standards (WOAH, d; WOAH, e; WOAH, f), and Guiding Principles for Animal Welfare (WOAH, g) which include

(inter-alia) that the use of animals carries with it an ethical responsibility to ensure the welfare of such animals to the greatest extent practicable. They also include the internationally recognized Five Freedoms (freedom from hunger, thirst and malnutrition; freedom from fear and distress; freedom from physical and thermal discomfort; freedom from pain, injury and disease; and freedom to express normal patterns of behavior) as valuable guidance to the welfare of animals. An examination of the "Five Freedoms" shows that the negative states which many of these describe simply cannot be avoided in these "factory farms" (WOAH, e).

In order to facilitate confinement of animals in such stressful, crowded conditions, painful non-therapeutic mutilations are routinely carried out to try to adapt animals to their environment – instead of adapting the environment to the animals' needs. These include procedures such as cutting off the horns of cattle, the beaks of chickens, and docking the tails of sheep, pigs, and indoor feedlot cattle (Nordquist et al., 2017). Pain relief is rarely provided.

WOAH considers that animal health and welfare are cornerstones of sustainable animal farming (World Organisation for Animal Health (WOAH), 2024). In the future, animal welfare scientists will play an integral role in ensuring that animal welfare becomes the foundation rather than a mere component of sustainable livestock systems. This will mean that consumers will be assured of humane and sustainable food, farmers can produce animals in line with their core ethical values and, most importantly, animals themselves can have a life worth living (Hendriks et al., 2025).

Animal welfare is currently largely disregarded in the 2030 Sustainable Development Agenda (United Nations Sustainable Development Goals) and yet research has shown that Good Practices for Animal Welfare in Agricultural Development Projects support the implementation of sustainable production systems, which are beneficial for humans, animals and the environment; and that these will assist the achievement of most, if not all, of the Sustainable Development Goals (SDGs) (Cox, 2019).

The 2019 Global Sustainable Development Report (GSDR) (United Nations, 2019) highlights animal welfare as an issue to be addressed by the UN System and states that "Strong governance should safeguard the well-being of both wildlife and domesticated animals with rules on animal welfare embedded in transnational trade."

The UN Secretary General himself stated in his 2020 report on "Harmony with Nature that: "A first step to recognizing the rights of Nature is the recognition that non-human animals are sentient beings, not mere property, and must be afforded respect and legal recognition" (Secretary General, 2020).

UNEP has also taken action on the nexus between animal welfare, the environment and sustainable development. On 2 March 2022 the United Nations Environment Assembly adopted a resolution on the subject: 5/1. Animal welfare–environment–sustainable development nexus (United Nations Digital Library, 2022) - acknowledging that animal welfare can contribute to addressing environmental challenges, promoting the One Health approach and achieving the SDGs.

4.3 Diseases and pandemics

These industrial systems which keep large numbers of (usually genetically similar) animals in crowded, stressful and unhygienic conditions can lead to the emergence, transmission, and amplification of both viral and bacterial diseases, some of which are zoonotic (Espinosa et al., 2020). Similar health risks occur at different stages of the food chain – including at markets, in transport and at slaughter. Although rarely considered, health risks are also caused at the feed production stage for industrial agriculture, where huge amounts of soy and cereals are produced causing the expansion of farmland into forests and other wildlife habitats. This results in ecosystem disruption and loss of biodiversity, both of which increase the risk of pathogen spillover (Benton et al., 2021).

COVID-19 was a devastating global pandemic which brought into sharp focus the existential threat to human health and lives from zoonotic diseases. However, it was preceded by a raft of other zoonotic diseases, with 75% of all emerging infectious diseases being shared between humans and animals (The Animals' Manifesto Preventing COVID-X). The July 2020 report by UNEP and the International Livestock Research Institute (ILRI) on "Preventing the Next Pandemic" identified unsustainable agricultural intensification and increasing demand for animal protein as major drivers of zoonotic disease emergence (UN Environment Programme (UNEP) and the International Livestock Research Institute (ILRI), 2020).

Another serious health problem that has arisen through the industrial agricultural industry routinely using antimicrobials in the feed or water of animals to prevent disease (and to promote growth) is antimicrobial resistance. Over 70% of global use of antimicrobials is in animals. This high use of antimicrobials contributes significantly to the emergence of bacteria that are resistant to antimicrobials, which can have devastating impacts on human health (Zhao et al., 2020).

High welfare systems which provide for the needs of the animals can avoid this large-scale use of antimicrobials (Stevenson, 2023). The problem can also be addressed through plant-based diets; and reduced through lower rates of consumption of higher welfare animal products.

4.4 Food loss and waste

Despite such high impacts and costs, a third of global food production is lost or wasted annually, making food loss a key contributor to global food insecurity (FAO, 2011). Another even more significant production-side food loss issue which is rarely addressed by policy-makers is the opportunity cost of feeding human-edible crops to animals to produce meat and dairy products. For every 100 calories fed to animals as cereals, only 17 to 30 calories enter the human food chain as meat (World Federation for Animals). Studies have shown that if the cereals used as animal feed were used for direct human consumption, they could feed an additional 3.5 billion to 4 billion people each year (Nellemann et al; Cassidy et al., 2013).

The International Resource Panel (IRP), which was launched by UNEP to build the knowledge needed to improve the use of resources worldwide, has stressed the high resource cost of consumption of livestock-based food, giving an example of grain being used as animal feed for livestock production which is then consumed by humans, instead of directly consumed by humans; and pointing out that population growth, expansion of cities, and dietary shifts to unhealthy and unsustainable consumption, will increase the pressures even more (International Resource Panel).

4.5 Hidden costs and funding for industrial animal agriculture

In reality, consumers of industrially-produced food are paying for this three times: once when they buy the food, once in the hidden costs (social, health, environmental and animal welfare), and finally with their taxes with which governments subsidize the agricultural businesses involved.

The UN has estimated the hidden environmental, social and health costs in our food and farming systems to be at least $10 trillion. Indeed, they are probably more, given the existential nature of the environmental crisis (World Economic Forum; FAO, 2023b). Conversely, research has shown that a substantial uptake of plant-based milk, meat, and eggs would lead to increased economic growth and job creation (Faunalytics).

Yet governments, international development organizations, the world's largest banks and international financial institutions – including the World Bank Group – are still subsidizing industrial food systems. They allocate billions of dollars to carbon-intensive industrial livestock companies, undermining their pledges to cut GHG emissions and fueling an increase in meat and milk production that threatens global climate goals (Grain and IATP; Feedback, 2020).

This despite the fact that SDG 12 on "Ensure sustainable consumption and production patterns" includes a target (12B) which covers removing market distortions that encourage wasteful consumption; and specifically includes phasing out harmful subsidies (The Global Goals; United Nations Department of Economic and Social Affairs).

The Convention on Biological Diversity also refers to harmful incentives or "perverse" incentives, with Target 18 requiring their identification by 2025, and elimination, phase-out of reform (progressively reducing them by at least 500 billion United States dollars per year by 2030) (Convention on Biological Diversity, a; Convention on Biological Diversity, b).

However, there is increasing pressure for disinvestment from industrial animal agriculture, including a new civil society coalition named "Stop Financing Factory Farming." They studied the investments of 16 the world's leading multilateral finance institutions – including The World Bank Group, the European Investment Bank (EIB) and the US Development Finance Corporation; and found that their support for industrially-farmed livestock systems was reduced by 46% from 2023 to 2024, although they still received five times more funding than sustainable systems (Stop Financing Factory Farming).

5 Traditional African food systems and values

Livestock development in Africa presents a paradox. While livestock is a cornerstone for economic advancement, the push for industrialized agricultural practices - modeled after the Global North - has brought significant harm to environmental sustainability, and human and animal well-being. This paradox underscores the tension between economic growth, which prioritizes short-term quantitative increases in output, and Africa's sustainable development, which should improve quality of life into the future.

Agriculture is a critical sector across Africa. In 2022, it accounted for approximately 17% of the continent's economic output, and generated livelihoods for around 70% of households. Yet Africa has remained the most food insecure continent in the world, with approximately one in four people undernourished. FAO indicated that (in 2022) approximately 868 million Africans experienced food insecurity, with 342 million severely affected (African Development Bank, 2024).

Food security cannot be realized into the future with the current trend that overemphasizes increased monoculture commodity production at the expense of downstream activities including value addition – with Africa exporting raw ingredients without value-added processing, and still importing many food items; and without tackling Africa's massive food waste problem and the need for nutritious and varied diets (Gonzalez, 2004b; African Union, 2019; EAT-Lancet Commission, 2019).

5.1 Traditional food sources

Traditionally, African food systems have been predominantly plant-based, with limited reliance on animal-sourced foods. This dietary pattern has contributed to the continent's comparatively low carbon footprint. However, many of Africa's nutritious, low-impact cereals and pulses are now being displaced by high-footprint crops (including monocultures for industrial livestock feed) introduced through the Global North's agricultural influence (Oniang'o et al., 2025).

5.2 Traditional roles of livestock in Africa

Animals in Africa serve multiple functions, which are not always captured by GDP. Robust, genetically diverse African cattle are treasured assets for an estimated 800 million livestock keepers across the continent. They are traditionally multi-purpose - providing milk, meat, skin and fiber for the household, much needed income, nitrogen-rich manure for replenishing soils and draught animal power for cultivation of fields. They also have traditional importance as a wealth store, and serve as a source of risk management, especially during times of drought or unforeseen large financial expenses (Salmon, 2018; Shava, 2019).

Smallholder farmers, who produce food, cash crops and rear livestock, are the primary food producers for subsistence and local markets in many African countries. They mostly rely on traditional farming methods to grow food. The United Nations (UN) Commission on Sustainable Development (CSD) and other major international organizations now recognize the significance of smallholder farmers in ensuring food security for poor households and a global sufficient supply of food (Kapari et al., 2023).

Pastoralism is also an important form of agriculture in Africa, as in many developing countries. It is the main livelihood in the arid and semi-arid areas of Eastern and Southern Africa. Over 90% of the meat consumed in East Africa and more than 50% of the milk produced comes from pastoral herds (FAO, d).

Pastoralism is among the most sustainable livestock systems, helping protect natural capital across a quarter of the Earth's land. Yet in many developing countries, decades of underinvestment and misguided policies have eroded this role - undermining herd mobility, weakening resource governance, and limiting access to essential services. The multiple roles of pastoralism are overlooked by narrow sectoral approaches, leading to decisions that are inefficient at a systems level, and have unintended adverse impacts on sustainability. Enabling conditions are needed for pastoralism to fulfil its potential, but intensification and expensive new technologies are not the answer (McGahey et al., 2014).

5.3 Culture and context/Ubuntu, Ukama, and ethical livestock development

The African philosophy of Ubuntu is an important cultural and traditional value emphasizing interconnectedness and respect for all living beings. To be human includes harmonious relationships with other humans, and non-humans (Khomba, 2011; Horsthemke, 2015). Traditionally, Ubuntu guided communities in their treatment of animals, recognizing them as sentient beings deserving of care. The erosion of this value system in farming has coincided with the adoption of industrial practices that result in animal suffering.

Ubuntu is also considered part of the lesser-known but important concept of Ukama (Carstens and Preiser, 2024). Ukama is an African philosophy or ethic of holism and relationality, stemming from the Shona word, Ukama, meaning relatedness (to the whole). Ukama is an intergenerational concept which rests on the premise that since generations that went before provided for the next generation, the present generation has the relational obligation to extend this same care to the existing and following generations.

Ukama is already being examined in the context of sustainable development, due to its holistic approach to development and contribution to decolonization. For example, IDDRI, an independent policy research institute and multi-stakeholder dialogue platform that identifies the conditions and proposes tools to put sustainable development at the heart of international relations and public and private policies, has established a Ukama platform. This brings together diverse African and European experts to explore related perspectives of Europe-Africa cooperation, including Climate, Sustainable Development, Economic Transformation, International Cooperation, Finance and Trade (IDDRI).

Ubuntu and Ukama are strong African cultural values which can be used to provide an ethical and ecological lens to evaluate and guide future food system transformations in Africa, and indeed globally, including humane and sustainable livestock practices.

There is also the Animal Welfare Strategy for Africa (AWSA) (African Union, 2018), which has been agreed by the African Union. This advocates for policies that protect animal welfare, emphasizing that the welfare of animals is intrinsically linked to human well-being and environmental health. This strategy underscores the interconnectedness of all life, resonating with the principles of Ubuntu and Ukama and supporting a holistic approach to livestock development. The vision of this strategy is:

"An Africa where animals are treated as sentient beings, as a leading continent in implementation of good animal welfare practices for a competitive and sustainable animal resource sector."

6 One Health

The internationally-agreed One Health policy is coordinated by the "Quadripartite" consisting of the WHO, FAO, WOAH and UNEP. The agreed definition of One Health (WHO, b) recognizes that "the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent"; and that it is "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems." (WHO, c; WHO, 2023) This is in accord with the principles of Ubuntu and Ukama.

7 The need for food systems transformation

Back in February 2012, a report was prepared for the UN's Department of Economic and Social Affairs Division for Sustainable Development on the future sustainability of food and agriculture (United Nations Department of Economic and Social Affairs Division for Sustainable Development). The ideas put forward in the report were widely shared by the world's leading scientists and thinkers on agricultural development, and stressed the need to update the way we manage the intrinsically intertwined food and environmental systems. The common conclusion was that: "To handle growing food demand, it is clear that 'business as usual' is not a viable option."

Since then, there has been increasing awareness of the need for a just transition towards food system transformation in line with sustainability objectives (UNEP, 2019). Just transitions are complex, and are viewed through different lenses and perspectives, and need to consider all aspects of sustainability. Thus, they need to be holistic and not siloed (Tribaldos and Kortetmäki, 2022).

As regards what is needed for food systems transformation, the Global Environmental Outlook (GEO) - a global review of the state and direction of the global environment spearheaded by UNEP and using leading environmental scientists – is in the process of preparing its 7th global assessment – GEO7: Action for a Healthy Planet – which is due to be released at the 7th UN Environment Assembly in December 2025. This will include food system transformation pathways (including shifting subsidies and their impacts on natural resources, shifting finance to environmentally sustainable agriculture practices, reducing food loss and waste and transformational change related to food consumption, including shifting to plant-based protein or cultured meat and seafood – "thus promoting health and nutrition co-benefits, food security co-benefits, and greater geopolitical stability") (UNEP, b).

8 Alternative pathways: the 3Rs framework

The authors propose a framework based on the internationally accepted 3Rs - Reduction, Refinement, and Replacement - to guide the development of food systems that are humane, sustainable, and aligned with Ubuntu, Ukama and One Health principles.

The 3Rs concept was originally developed by Russell and Burch in 1959 as a formula for minimizing the potential for animal pain and distress in biomedical research, by a proposed new applied science that would improve the treatment of laboratory animals, minimize the numbers of animals uses, whilst advancing the quality of science in studies that still used animals (Tannenbaum and Bennett, 2015). Central to Russell and Burch's definitions of the 3Rs are two concepts: inhumanity and its opposite, humanity. Humanity, as Russell and Burch understood it, is the ultimate goal of the 3Rs (Russell and Burch, 2009). The 3Rs concept is now increasingly extended to cover other areas of animal use, including food systems, livestock and waste (Cox, 2015; Iliná et al., 2023).

This paragraph includes a brief overview of how the 3Rs could be applied to food systems transformation, with more specific examples below for the African situation.

Reduction: Addressing food waste and incrementally adopting alternatives to animal products (including more plant-based diets) are important aspects. People not yet ready to forego their livestock products can make a partial reduction. For example, through smaller portion sizes (but choosing quality products – so eating less but "better" meat), adopting a "flexitarian diet (eating and drinking more plant-based alternatives) and through "blended" (or hybrid) meat-plant products (Grasso, 2024).

Refinement: This has to include a move away from industrial animal production, which cannot provide good welfare for animals. Improving animal welfare and ecosystems through better systems and management practices is essential (including regenerative agriculture practices such as agroecology, rotational systems and silvopastoralism). Investment in animal health and welfare is crucial to achieving this goal, supported by better regulation, research and extension.

Replacement: Replacement of animal-sourced foods with alternatives (Abbaspour et al., 2023), including meat and dairy substitutes (such as vegetable burgers, sausages etc. and plant-based milks), plant-based replacements (plant-based options with similar nutritional properties, such as tofu, soya products etc.), meat or dairy analogues (which mimic their texture, taste, and appearance), other alternatives (for example, drinking apple juice instead of milk) and cellular/cultivated meat – where meat is produced directly from cells and precision fermentation. Cellular/cultivated meat would be vastly more efficient and environmentally-friendly than conventional meat production, and avoid many of its other detrimental impacts, such as animal welfare and human health harms (including disease and pandemic risk and antimicrobial resistance) (Good Food Institute; Pro Veg; UNEP, c).

8.1 Reduction

It is clear that people are unequally able to make a shift towards plant-based diets. This is not only a case of poverty and wealth, but also mindsets. As indicated above, traditionally, African food systems were predominantly plant-based, with limited reliance on animal-sourced foods. Livestock was slaughtered only on special occasions. However, meat consumption has developed into a cultural norm in many parts of Africa, particularly in urban areas, being linked to aspirations of wealth and status (emulating the Global North). In the case of South Africa, there is the ubiquitous "braai" (barbeque). But on the other hand, record numbers have reduced or eliminated meat in their diets, and this is catered for in major supermarkets, restaurants and even local markets. For some citizens this is viewed as "decolonializing their diets", and as a response to experiencing first-hand the impacts of climate change (Yount-André and Zembe).

Africa, by default, with a population that has minimal access to animal sourced foods (ASF), should lead in developing and adopting meat and dairy alternatives. Leveraging indigenous crops - including African superfoods - for plant-based diets offers more sustainable and nutritious options. Embracing such innovations, alongside efforts to reduce ASF consumption, can diversify diets, mitigate the environmental and public health impacts of livestock farming, and redirect feed crops toward direct human consumption to alleviate food insecurity.

However, it is important to acknowledge and address food and nutrition insecurity across many African regions, particularly among vulnerable populations where micronutrient deficiencies are prevalent. Nearly 282 million people in Africa (about 20 percent of the population) were undernourished in 2022. About 868 million people were moderately or severely food-insecure and more than one-third of them – 342 million people – were severely food-insecure (FAO et al., 2023). Therefore, ethical, high animal welfare ASF will still play a role in Africa's food systems. This links to "Refinement", because industrial systems have been shown to be unsustainable, and will cause greater food insecurity into the future; and so, need to be phased out in favor of humane and sustainable - regenerative - systems. Additionally, African palates and cultural preferences may resist rapid shifts to novel food alternatives, underscoring the need to invest in public awareness and mindset transformation to foster gradual and inclusive dietary change.

Public awareness campaigns, such as "Eat Less Meat" initiatives, have the potential to reduce the environmental impact of livestock farming. Such strategies are primarily targeted to the Global North which has over-consumption to be addressed, rather than Africa, given its per capita nutritional insufficiency and low rates of meat consumption. However, obesity rates are rising in wealthier pockets of Africa, so it is important not to emulate the over-consumption patterns of the Global North. Indeed, many low- and middle-income countries are already facing a so-called "double burden of malnutrition" with over-consumption and obesity amongst parts of the population, and hunger in other parts (Seferidi et al., 2022).

One area where gains could be won, based on cost advantages, would be blended/hybrid products (meat/plant-based). This is not often spoken about in the context of reduction, but it is happening in practice: mainly to address meat shortages and reduce costs. Household often cook mixed meat-plant dishes, which are cheaper and nutritious. Blended products are also sold – but sometimes not labeled. In South Africa, for example, "beef' samosas often contain texturized vegetable protein (soya), sometimes these incorporate small amounts of beef (as the large supermarket chain Checkers - at 10% beef) (Checkers Supermarket), and in other instances they include no beef.

8.2 Refinement

The intention is that regenerative agriculture is farming with nature rather than against it, in a way that restores and rebuilds agricultural ecosystems. Supporters consider it to be a system of farming that goes beyond organic farming (which focuses on farming without certain deleterious inputs, using natural processes); because it aims to reverse the decline of an agroecosystem and establish a new ecology that is continually restoring itself (Kabenomunhangi, 2024). This system increases yields and resilience to climate change. In a nutshell, it is agroecology with a restorative aspect, which ensures future sustainability.

Regenerative livestock farming would include systems such as agroecology, rotational systems and silvopastoralism.

Agroecology: Agroecological systems would ideally provide sustainable production in environments that supply the needs of the animals resulting in good welfare, allow coexistence with a wide diversity of organisms which are native to the area, and minimize carbon footprint. There is potential for great increases in biodiversity in farmed areas.

Rotational farming: Rotational farming was traditionally practiced for both crop-livestock farming and different crops. African communal farmers are deeply attached to the legacy of rotational grazing, and the elders retain knowledge of the practice. However, in practice, rotational grazing has greatly diminished. Yet some new conservation initiatives are supporting the revival of this tradition, particularly as a strategy to minimize soil erosion and land degradation and increase biodiversity (McCarry, 2023).

Silvopastoral systems: Silvopastoral systems are feasible in more fertile areas of Africa. They contain pastures with shrubs and trees as well as herbage, are normally more productive than pasture alone, and have significant benefits for climate change and biodiversity (Balehegn et al., 2021; Baptista and Ferraz de Oliveira, 2021). Less land is required because dry matter production in silvopastoral systems is 27% higher than monoculture pastures. Additionally, silvopastoralism requires fewer agricultural inputs, such as fertilizers and pesticides, and less upkeep than monoculture pastures. Additionally, such systems can be more productive than extensive grazing. For example, silvopastoral systems lead to a higher milk production in cows than standard monoculture pastures (The World Bank Group, 2021).

Regenerative agriculture is feasible in Africa with targeted support - African-specific research, policies, funding, skilled extension services, and a stronger focus on animal welfare, health, and ethnoveterinary knowledge. Livestock sustainability also depends on improving forage and rehabilitating rangelands and grazing areas.

It makes sense to champion higher welfare, lower input systems that decreasingly depend on the production of animal feed. Grass-based and mixed-farm systems have much greater capacities for carbon sequestration, local breeds adaptable to local climate conditions have lower emissions per unit of production, and healthy livestock produce more and emit less. According to UNEP, "reducing intensively farmed meat consumption is good for people and the planet." (UNEP, d)

There have been various notable initiatives to enhance livestock improvement and sustainability in Africa.

Botswana and Namibia have both developed a reputation for competitive livestock value chains which strive for sustainability, including environmental and social inclusion dimensions – with extensive grassland systems. They have export markets for their beef, particularly in the European Union. Their industries are well-organized, meet quality and sanitary requirements of high-end markets, and have good animal identification and traceability systems in place (Syed et al., 2022). Botswana's advantage is based on well-managed supply chain management and traceability, and Namibia's centers on certification and labeling, including Farm Assured Namibian Meat (FAN Meat), whose standards are set and administered by the Meat Board of Namibia (The Livestock and Livestock Products Board of Namibia. About FAN Meat), and Natures Reserve (Jan Zandbergen Group, a; Jan Zandbergen Group, b).

South Africa has introduced a certification scheme based on animal welfare criteria. The Certified Animal Welfare Approved by A Greener World is the only label in the country that guarantees animals are raised outdoors on pasture or range for their entire lives (A Greener World).

8.3 Replacement

Replacement brings optimum opportunities for delivering economic, health, environmental and animal welfare benefits, and increased sustainability. As can be seen above, the replacement of meat and dairy products can take many forms, and choice will depend on each person's main criteria: health, convenience, taste etc.

Plant-Based Alternatives: Plant-based solutions include highly nutritious products such as tofu, soya, tempeh, lentils and pulses. There are already many tasty and nutritious plant-based dishes in Africa. There are also plant-based African superfoods such as

moringa, teff, amaranth, fonio, baobab, tamarind, coconut and pumpkin leaves which have natural health and nutritional benefits and a variety of adaptive and resilient properties (Ekesa, 2017). However, these are often used for high-value business opportunities, including export (Maritz, 2022) - despite the fact that they are much needed for local food security. Optimal utilization of nutritious indigenous and traditional foods holds the potential for diversifying Africa's food systems, especially if more of these can be domesticated and produced in larger quantities. There is an urgent need to create pride in and demand for these foods, and investment in research and development across the food system to integrate these resources into the daily food basket of African communities.

The FAO has compiled a "Compendium of Forgotten Foods in Africa", to support the integrations of Africa's forgotten foods for better nutrition. They named them "forgotten foods" because they are forgotten by the research funders, researchers and development practitioners." (FAO, e)

Meat and Dairy Substitutes and Analogues: There is an increasing number of meat and dairy substitutes and analogues available in supermarkets and restaurants in Africa. The Africa dairy alternatives market is growing, and expected to reach 488.20 million US dollars in 2025 and grow at a compound annual growth rate of 7.11% to reach 688.27 million US dollars by 2030 (Mordor Intelligence). Different versions of plant-based meat products have been available in Sub-Saharan Africa over the past 25 years; these include burgers, sausages, nuggets, mince and meatballs. However, there remain barriers to their broader acceptance, with consumers' preference for meat as the most significant barrier; exacerbated by the important socio-cultural connotations of meat-eating and the perception that meat is "natural" and these alternatives are processed. Price is another significant barrier to the adoption of plant-based meat alternatives. For example, these are considered expensive niche products in South Africa, associated with status and class (Omamuyovwi Gbejewoh et al., 2022).

Cellular and Cultivated Meat: Africa is trailing in the cellular meat sector. Mzansi Meat Co, founded in 2020 as the continent's first cultivated meat company, rebranded to Newform Foods in 2023, shifting from a consumer brand to a provider of cultivation technology. The company cites lack of funding and support as key barriers. While some countries have approved cultivated meat, it remains largely unavailable globally. Singapore, the first to approve such a product, leads the sector through strong government backing, investment, and innovation. Singapore continues to attract international collaborations and investments, positioning itself at the forefront of the alternative protein revolution (Good Food Institute (GFI)). Regulatory approvals are an essential element for market access, but few standardized best practices or technical recommendations have been established.

9 Barriers to food system transformation in Africa

Despite the range benefits and opportunities to be gained through food system transformation in Africa, there are barriers to the necessary just transitions towards humane and sustainable food systems; and the most important of these are considered below.

9.1 Policy

Policymakers from regional and national levels have not yet fully acknowledged the need for food system transformation in policy and practice. To do so would necessitate:

- New policy commitments, legislation and roadmaps for just transitions towards humane, sustainable and culturally-appropriate food systems (including tackling food waste, and support for value-added processing);
- Dealing with food systems holistically, instead of in silos;
- Prioritizing food security, before export and trade;
- "Decolonizing" the food system, including avoiding unfair trade agreements and developing local and regional trade systems; pressing for the removal of non-tariff barriers including the simplification of documentation and border compliance;
- Including transformation to humane and sustainable food systems within their national development plans and national climate action plans/NDCs;
- Public procurement that supports humane and sustainable food systems; and
- The development of local research and capacity building, particularly for policy makers; and strengthening extension services.

One factor that has contributed to the push for agricultural exports, instead of meeting food security needs is the need to boost economic growth (as measured by GDP). External debt owed by African countries to external creditors was 685.5 billion US dollars in 2023, equivalent to 24.5% of their combined GDP (One Data). One way of addressing this may be to ensure that ecological debt is used to repay national debts, as well as supporting food system transformation.

9.2 Funding

Multiple funding sources must be redirected to support humane, sustainable food systems. Despite some reductions, governments, development agencies, major banks, and global institutions still heavily subsidize industrial agriculture. Policy and funding shifts are needed to:

- Internalize externalities;
- Remove subsidies for industrial animal farming; and
- Redirect funds to small-scale producers, plant-based alternatives, and cultivated meat.

These funding streams are closely tied to Africa's own policy frameworks, especially national development plans.

There are also private foundations supporting industrial animal agriculture. For example, as many as 85% of Gates Foundation-funded agricultural research projects for Africa "were limited to supporting industrial agriculture and/or increasing its efficiency via targeted approaches," according to a 2020 report by the International Panel of Experts on Food Systems (IPES) (Biovision Foundation for Ecological Development & IPES-Food, 2020 2020). The foundation "looks for quick, tangible returns on investment, and thus favors targeted, technological solutions," IPES said. Just 3% of Gates Foundation projects included elements of agroecological redesign.

Change will not be easy as commercial and public banks, and "high tech" private funders remain supportive of the industrial model of animal agriculture. More scientific evidence is needed to present to these funders to persuade them that the funding of industrial animal agriculture is no more acceptable than financing fossil fuels; and that support needs to be repurposed to just, humane and sustainable food systems (Stevenson, 2024). Such evidence would include both the detrimental impacts of industrial animal agriculture and the economic and developmental benefits of food systems transformation.

Some work has already been conducted in this sphere, including by:

- The Food Services Economics Commission, who produced a 2024 Global Policy Report on "The Economics of the Food System Transformation" (Food System Economics Commission (FSEC)) which concluded that not only is a transformation of food systems urgently needed, but that this also offers enormous economic benefits: In the realm of 5 to 10 trillion USD a year, equivalent to between 4 and 8 percent of global GDP in 2020.
- The investor network FAIRR, which represents investors with $52 trillion of assets concerned about the long-term sustainability of animal-based agriculture, who published reports (February 2022 and April 2022) examining the sustainability of global livestock and dairy sectors in the light of climate change (FAIRR). They stated that, in a business-as-usual scenario, the global beef production sector will lose $38bn of value by 2050; and there will also be losses of $22bn for the dairy sector.
- Boston Consulting Group, whose studies confirmed the value of investing in alternative proteins as a climate change strategy in their report entitled "The Untapped Climate Opportunity in Alternative Proteins" (Boston Consulting Group).

9.3 Quantifying and securing ecological debt

A key difficulty is placing an economic value on the ecological debt owed by the Global North to Africa. Firstly, there is the difficulty of quantifying and attributing ecological (and other associated developmental) damage; and then there is a further difficulty in allocating the appropriate portion of this to Africa.

There have been some sophisticated methodologies for quantifying ecological debt, particularly carbon debt, by scholars. These were examined in a paper submitted to the International Society for Ecological Economics back in 2012, and a modified method suggested which is described as scientifically accurate, applicable on existing data, and user friendly (Warlenius). This focuses on emissions, rather than the entirety of ecological debt, but it clearly indicates that the developed countries have an immense emissions debt.

The FAO's 2023 report on the "State of Food and Agriculture" estimates the expected value of the global hidden costs of agrifood systems in 2020 – from GHG and nitrogen emissions, water use, land-use change, unhealthy dietary patterns, undernourishment and poverty – at 12.7 trillion 2020 Purchasing Power Parities US dollars. This value was almost 10 percent of global GDP PPP in 2020 (FAO, 2023c).

It appears that the significant size of ecological debt is likely to be a political barrier. Thus, what is of key importance is the political acceptance of the concept, and progressive application towards adequate restorative justice.

9.4 Dietary change

Dietary change is complex, shaped by culture, identity, and ethics. Meat consumption has developed into a cultural norm in many parts of Africa, particularly in urban areas, being linked to aspirations of wealth and status. In many cases, campaigning for Africans to "Eat Less Meat" (or stop eating meat) may have an adverse effect; so, any interventions would need to be grounded in sociological research and use positive, supportive messaging.

Alternatives are largely considered in terms of meat analogues, and considered expensive, overly processed, and less desirable. There is limited public awareness of the environmental, health, and animal welfare impacts of livestock, or the benefits of dietary change.

To shift perceptions, plant-based meals and African superfoods must be made appealing and trendy. Possible strategies could include media and social media campaigns; endorsements by celebrities and influencers, popular recipes, fun meat-free days, and strong education and awareness efforts.

10 Conclusion

Industrial agriculture was introduced in the Global North after World War II with a narrow focus on food production, neglecting its broader, interconnected impacts. These systems were later exported to the Global South, where they now contribute significantly to the "triple planetary crisis" of climate change, pollution, and biodiversity loss - crises disproportionately driven

by the Global North but more severely affecting the Global South, especially Africa.

Industrial livestock production has further harmed both human and animal health, undermining traditional African livestock practices and cultural values such as *Ubuntu* and *Ukama*, which promote interconnectedness and align with One Health principles.

There is a growing call for the Global North to acknowledge its moral and financial obligation to provide restorative justice through ecological debt. This debt should be used to support Africa's transition to just, humane, and sustainable food systems - systems that promote human, animal, and environmental well-being and reaffirm vital cultural values.

Although food systems transformation is now recognized as essential, the Global North faces deep-rooted industrial models and overconsumption that will take time to dismantle. In the meantime, it is critical to prevent these unsustainable models from becoming further introduced and entrenched in the Global South.

The proposed 3Rs framework — Reduction, Refinement, and Replacement — offers a path toward a just transition. Yet in Africa, major barriers remain, including:

- Policy: Limited understanding, commitment, and implementation.
- Funding: Continued subsidies for industrial agriculture instead of investment in just transitions.
- Ecological Debt: Challenges in quantifying, securing, and politically accepting the concept.
- Dietary Change: Deep-seated cultural and personal barriers.

Overcoming these challenges will require targeted research, bold policy shifts, and inclusive, values-based action.

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