# Sustainable Livestock Solutions Cluster: Stakeholder Group C: Solutions that aim to optimize and align consumption and production so that the sector stays within all planetary boundaries and contributes to ensuring healthy diets for all.

## Objective

The objective of this Solution Cluster is to seek support for creation of a broad-based multi-stakeholder coalition to develop, model and implement cohesive and integrated measures that promote consumption and production of affordable, healthy diets within safe planetary boundaries from humane and regenerative farming methods.

Research shows that the production of animal sourced foods needs to be reduced by at least half globally to stay within environmental limits and planetary boundaries.[1] This global reduction should be undertaken on a contraction and convergence basis. This would enable increased consumption of humanely and regeneratively produced animal-source foods in some countries and regions and substantial reductions amongst high-consuming populations in accordance with healthy dietary guidelines. [2] [3] [4] [5]

Regenerative agricultural practices are contributing to successful transformation of farms, soils, biodiversity, animal welfare and livelihoods all over the world. Yet industrial animal agriculture dominates food systems, posing serious threats to soils, waterways, biodiversity, animal welfare and human health.

Accelerating transition to regenerative, agroecological production is an essential component of future sustainable and resilient food systems that operate within safe planetary boundaries.[6]

## The problem this Solution Cluster is trying to address

Livestock production is the main driver of, or a major contributor to, biodiversity loss, deforestation, climate change, soil degradation, and overuse and pollution of water. It contributes to key non-communicable diseases and antimicrobial resistance as well as increasing the risk of future pandemics. Impacts include:

- **Land use** - around three-quarters of global agricultural land is dedicated to animal agriculture.[7]
- **Climate change:** The UN Food and Agriculture Organisation (FAO) reports that livestock are responsible for 14.5% of global GHG emissions.[8]
- **Resource inefficiency:** Globally according to FAO data 33% of the world's grain is used to feed animals, with other studies reporting 40-45%.[9] [10] Animals convert this very inefficiently into meat and milk.[11] [12] This undermines SDG 2's aim of achieving food security. If the grain used as animal feed were instead used for direct human consumption an extra 3.5 billion people could be fed each year.[13] [14]
- **Environmental degradation:** The large feed needs of livestock are contributing to biodiversity loss,[15] [16] soil degradation[17] [18], overuse and pollution of water[19] and air pollution[20], thereby undermining SDGs 2, 6, 14 and 15.
- **Deforestation:** Industrial livestock's huge demand for soy, plus a growth in cattle ranching, has led to the expansion of farmland into forests and other key habitats. 77% of global soy is used as animal feed, mainly in the intensive pig and poultry sectors.[21] This undermines SDGs 12 and 15.
- **Antimicrobial resistance:** Globally, over 70% of all antimicrobials are used in farm animals.[22] Industrial production depends on the routine use of antimicrobials to prevent the diseases that are inevitable when animals are kept in poor conditions. This leads to antimicrobials resistance in animals, which can then be transferred to people.
- **Non-communicable diseases:** High levels of consumption of red and processed meat contribute to heart disease, obesity, diabetes and certain cancers.[23, 24, 25] [26] [27] [28] [29] [30] [31] [32] This undermines SDG 3.

**What are the components of the Solution Cluster? How do they work alone and together?**

The Solution Cluster proposes that cohesive and integrated action be taken in four key areas to support transition towards resilient food systems that promote public health by focussing on provision of affordable healthy diets for all produced from sustainable, regenerative and humane farming practices.

**Action Area 1: Resize the livestock industry**
Resizing of the livestock industry should be supported by policy measures that encourage both less and better production and consumption of livestock products and reflect both the negative and beneficial externalities of livestock production. For example, by reorienting agricultural subsidies to incentivise the production of more sustainable, humane and climate-friendly foods including sustainable protein production; updating national dietary guidelines to ensure that recommended diets are both healthy and sustainable; utilising public procurement to influence change and by promoting and subsidising healthy, sustainable and plant-rich dietary choices whilst discouraging unhealthy choices. This would not only reduce the harms to environment caused by excessive livestock production but deliver health benefits by reducing the incidence of heart disease, obesity, type 2 diabetes and certain cancers. [33] [34] [35] [36]

It is also a priority to prevent further unsustainable intensification of animal agriculture in the Global South. If not addressed, it could increasingly threaten the livelihoods of millions of small-scale farmers whom large-scale producers usually outcompete.[37] The massive amount of land required for industrial-scale livestock — both pasture and animal feed production — leads to increased land concentration by large meat and feed producers headquartered or with substantial operations in the Global North at the cost of small-scale farmers (especially women and Indigenous Peoples). This process is often associated with land conflicts, the loss of livelihoods and compromised food sovereignty.[38] Smallholder farmers must be helped to increase their productivity through regenerative agriculture, which can increase yields while reviving degraded land.

**Action Area 2: Shift towards regenerative, agroecological farming systems**
Regenerative Agriculture (RA) approaches show the potential to be able to significantly transform the current global food system. At their core, regenerative farming practices seek to move away from a monoculture focus to a landscape approach, in which crops, and grazing pastures rotate, mixed crop-livestock systems thrive, biodiversity is prioritised, and soil health is restored. This landscape approach involves looking at the entire ecosystem to create holistic interventions.

The livestock sector must undergo a dramatic transformation to become genuinely sustainable and nature-positive, for example, with farmed animals being reared on the land consuming foodstuffs that humans cannot eat, such as pasture and genuine byproducts in regenerative systems such as agroecology, agroforestry, organic farming, low intensive permanent grassland, and rotational integrated crop-livestock farming. This said, the amount of land devoted to pasture-based livestock production globally needs to be balanced with that required to support natural climate solutions such as restoration of forests and peatland.[39] Good grassland systems do not feed grain to the animals and minimise the use of chemical fertilisers.[40] In such farms the animals are fed on grass, genuine crop residues and root crops grown on the farm. Soil fertility and the nutritional quality of the grass are built through animal manure, the ability of the roots of grasses to collect minerals from deep in the soil and the inclusion in the grass of herbs, wildflowers, and protein-rich legumes such as clover.

**Action Area 3: Support a Just Transition**
Despite the urgent need to transition towards nature-positive and plant-forward farming, there are concerns about the possible negative socio-economic impacts of the transition among farmers, supply chain workers and government ministers. These concerns should be addressed by engaging in multilateral dialogues and showcasing pathways for an equitable transition for farmers, growers and processors and how this can enable positive socio-economic changes, including job creation and GDP boost.[41] [42]

A recent assessment by the International Labour Organisation and Inter-American Development Bank predicts that a transition to plant-based diets would create 15 million jobs net in Latin America and The Caribbean[43]. Overall, given the range of health and occupational risks present in animal protein supply chains[44] [45] [46], the additional jobs in plant-based food production have the potential to be safer, more equitable, support gender parity and strengthen rural economies when coupled with increased public services.

Transition support should be provided for farmers no longer wishing to engage in livestock production, or who wish to diversify to regenerative integrated crop-livestock, silvopastoral systems, horticulture or alternative protein production.

Country-specific transition roadmaps must be developed using a systems-change approach not only in collaboration with farmers, but also in conjunction with workers, experts in nutrition, public health, environment, circular economy, gender and human rights as well as Indigenous Peoples and labour groups to better envisage pathways to an equitable transition.

Ensuring more sustainable and equitable food production with respect to local environments and populations is key. While Just Transition in animal agriculture is important in every region and nation, the approaches must be tailored after thorough consideration of local realities and must respect community rights and decision-making. As in energy production, the onus is on G20 countries to facilitate the transition in their own countries and assist others, including the countries that trade with them.

**Action Area 4: Adopt good standards of farm animal welfare**

Good standards of animal welfare are increasingly recognised as a key element of genuine sustainability in livestock systems. Scope for high animal welfare can be found particularly in nature-positive farming. There is scientific recognition that the best kind of animal welfare entails not only avoiding cages and crates and overcrowding but also providing opportunities for animals to have positive experiences, to have a good quality of life and to be kept in conditions which facilitate their capacity for pleasurable feelings such as companionship.[47] The FAO has stated: "A paradigm shift has become urgent. Animals are to be addressed as living beings to take care of and valorize, not only as a source of commodities to exploit".[48]

Industrial production is dependent on routine use of antimicrobials to prevent the diseases that arise when animals are kept in poor conditions.[49] [50] Indeed globally, around 70% of all antibiotics are used in farm animals.[51] The stressful, crowded conditions of industrial agriculture contribute to the emergence, spread and amplification of pathogens. [52] This leads to antimicrobial resistance in animals which can then be transferred to people. Additionally, intensively reared animals are selectively bred to have nearly identical genomes and can act as vast replication vessels for some viruses.[53]

To prevent future pandemics[54] and safeguard the efficacy of antibiotics[55], we need to move to 'health-oriented' systems for rearing animals in which good health is inherent in the farming system, rather than being propped up by routine use of antibiotics. Such systems would avoid overcrowding and excessive herd and flock size. They would minimise stress, ensure that animals can perform their natural behaviours and enjoy a good quality of life. Such systems would not use routine mutilations such as castration, tail docking, teeth clipping and beak trimming.

A 'one health, one welfare' approach is needed for the benefit of human wellbeing, animal welfare and sustainability.[56] [57]

## What is needed to make the regenerative agricultural systems impactful at scale?

**1. Cohesive food policies:** Governments need to adopt policies that seek to provide healthy and climate-compatible food from regenerative and agroecological food systems. The core objectives of cross-departmental food policies that align consumption and production of healthy and sustainable diets should be enshrined in legislation together with specific targets to be met by specific dates. National Dietary Guidelines

should be updated to encourage adoption of healthy and sustainable diets with the proportion of animal-source foods not exceeding dietary and planetary health recommendations [58] [59] [60] Social policies should not be neglected. A report by the *International Panel of Experts on Sustainable Food Systems* stresses that "cheap calories can no longer be a substitute for social policies, which must be rebuilt and redesigned to tackle the root causes of poverty and promote access to healthy food for all".[61] National climate action plans, officially known as Nationally Determined Contributions (NDCs),[62] and National Adaptation Plans (NAPs) should be updated to include policies to enable regenerative production to provide foods for healthy and sustainable diets.

**2. A UN Agreement on food and agriculture:** Food and farming are cross-cutting issues that connect many of the world's sustainability and health challenges. Industrial agriculture and the Western diet are incompatible with the goals of the SDGs, the Paris Climate Agreement and the Convention on Biological Diversity.[63] A UN Agreement would help us break out of policy silos and would promote the development of cohesive food and farming policies that seek to fulfil a range of objectives. It would facilitate the proper integration of policies so that one objective is not achieved at the expense of another.

**3. Online resource of successful regenerative, agroecological, silvo-pastoral and organic schemes:** Information on existing schemes from around the world and how they operate and overcome challenges should be readily available.

**4. Public information and education**: Programmes are needed to increase public awareness of the implications of different livestock farming methods and consumption levels for human health, the environment, food security and animal welfare. This would be in line with SDG 12.8 which provides that people should have "the relevant information for sustainable development and lifestyles in harmony with nature".

**5. Labelling;** Consumers should be empowered to play a greater part in driving improvements in environmental sustainability and animal welfare. Mandatory labelling of meat and dairy products as to method of production would enable consumers to make informed choices.

**6. Public procurement:** Public sector bodies should use their buying power to augment the market for food produced to high nutritional, environmental and animal welfare standards. Public bodies' commitment to quality will help change our attitude to food. Improving the quality of public food does not need to increase costs. In Denmark, the *Copenhagen House of Food* is responsible for meals provided in the city's public sector. 90% of those meals are now organic.[64] By carefully balancing the contents of meals, they have been able to do this without increasing costs. [65]

**7. True cost accounting -internalising negative externalities:** According to a recent FAO Agricultural Development Economics Working Paper the health and environmental consequences of our dietary choices impose costs on society that are currently not reflected in the price of those foods or diets that contribute to these detrimental impacts. The 2020 paper provides updated estimates of two major cost items: the healthcare-related costs associated with unhealthy diets, and the climate-change costs associated with the emissions attributable to diets and food production. Results suggest that the health and climate-change costs of current diets are substantial and projected to increase up to 1.3-1.7 trillion USD annually by 2030.[66]

Olivier De Schutter, former UN Special Rapporteur on the right to food, stresses that "any society where a healthy diet is more expensive than an unhealthy diet is a society that must mend its price system." [67] This applies equally to a society where food that respects natural resources and animals' well-being is more expensive than environmentally damaging low animal welfare food.

The repurposing of subsidies is crucial. In September 2021, a new UN report, launched by the Food and Agriculture Organisation (FAO), the UN Development Programme (UNDP) and the UN Environment Programme (UNEP), advised that 87 per cent of global support to producers in the agricultural sector amounting to approximately USD 470 billion, includes both measures that are price distorting and those that can be harmful to nature and health.[68] The UN called for governments to rethink the way that agriculture is

subsidised and supported, calling for repurposing of these damaging incentives to achieve more of the 2030 Sustainable Development Goals and realize the UN Decade of Ecosystem Restoration.

Many bodies and reports have recommended using taxation to rebalance our food system.[69] [70] [71] [72] The use of taxation should be based on two interlocking principles:

- Internalisation of the costs generated by unsustainable farming methods and diets
- Provision of sufficient incentives and disincentives to promote systemic change.

Taxes should be placed on the damaging inputs of agriculture such as synthetic fertilisers and chemical pesticides and feed containing soy and human-edible cereals. Such kinds of feed as well as agro-chemicals are responsible for very substantial damage to the environment and human health. Accordingly, it is appropriate that taxes are placed on them to internalise these negative externalities. The funds raised by such taxes, and the repurposing of subsidies should be used to support farmers who produce nutritious food to high standards.

Taxes should also be placed on unhealthy food produced to low environmental and animal welfare standards with all the revenue raised being used to lower the price for consumers of nutritious, humane food produced to good environmental standards.

**8. Financial institutions:** Commercial and public banks, and investors provide huge sums to fund industrial livestock production although many institutional investors are trying to address the ESG risks in the animal agriculture sector[73]. Investors, including major institutional investors, invest heavily in industrial animal agriculture. Financial institutions and investors should stop funding, or phase out investment in, this type of production as well as engaging with portfolio companies to call for a time-bound transition towards more sustainable production systems. They should instead provide financial support for regenerative agriculture as well as alternative proteins from non-animal sources. A core problem is that public banks generally will only fund large projects or funds that require substantial sums of money. This steers them in the direction of large-scale, industrial agriculture. Banks should rethink this policy and develop ways of funding micro projects that benefit small-scale farmers.

**9. Trade policy reform:** Trade law can obstruct moves aimed at introducing sustainable and humane food policies, for example by making it difficult for countries to require imports to meet the sustainability standards placed on domestic producers. Reforms are needed to ensure that trade law incentivizes good practices (climate, livelihoods, biodiversity protection, animal welfare, protecting antibiotics) and disincentivizes bad practices (deforestation, biodiversity loss).[74]

**10. Introducing policies aimed at achieving a substantial reduction in the use of grain and soy to feed farmed animals.** Currently, some 33 - 45% of global cereals are used to feed animals, as mentioned previously; they convert them very inefficiently into meat and milk. [75] [76] [77] [78] [79] The use of grain and soy as animal feed should be halved by 2030 and be reduced by 75% by 2035.

**11. Introducing policies to support development and take-up of less and better animal source foods produced both humanely and sustainably and of alternative and plant-based proteins:** Governments should support the innovation, development and accessibility of such foods as these eliminate the risk of pandemics and antibiotics resistance associated with industrial livestock production.[80] **81**

## Which factors impede the scaling of regenerative agriculture?

Transformation of food systems is complex, as they have been shaped by historical processes. Our decisions are constrained by economic structures and existing infrastructures in which actors have invested. However, the need to change is urgent and it will be important to ensure that all stakeholders work together to develop ways to overcome barriers. Action in several areas will be helpful as outlined below.

## Moving towards more equitable food systems

Current benefits arising from food systems are not shared equitably across all actors. Large multi-nationals that provide inputs such as livestock feed (e.g., the major grain traders); animal genetics and pharmaceuticals including antimicrobials*;* fertilisers, pesticides and commercial seeds; and farm equipment (including cages for industrially farmed animals) profit hugely from the status quo of industrial agriculture. If we moved to regenerative farming, which relies much less on inputs, farmers would still be needed but the demand for the products of these multi-nationals would fall very substantially. Even companies that provide inputs for crop production such as chemical fertilisers and pesticides need industrial livestock production to continue at its current level as a substantial proportion of their products are used in the production of crops that are grown for animal feed. In addition to these input providers, large corporate producers of meat and dairy have a vested interest in the continuation of the industrial model of livestock production and in promoting rising levels of meat and dairy consumption.

These companies have immense political influence which they use to influence policymakers and to obstruct reforms. They can shape the narratives that entrench the status quo e.g., 'industrial agriculture gives us cheap food and is vital to feed the world'. The *Alliance for Food Sovereignty in Africa* states "the strongest resistance to agroecology comes from the vested interests of the industrial food system, who have used their huge economic power to convince African governments that industrial agriculture is the symbiotic way to go".[82]

Long-standing supply chain infrastructure being built around intensive specialized systems provides yet another lock-in acting as a barrier to change.

## Disrupting the reinforcing feedback loop between cereal production and industrial animal agriculture.

An unhealthy relationship of mutual dependence exists in the developed world (and certain emerging economies) between the arable and the industrial livestock sectors. In the U.S. and the EU around two thirds of cereals are used as animal feed, mainly in the industrial sectors. If EU and U.S. animal production were to move away from the use of cereals as feed, their cereal sectors would experience the loss of much of their principal markets. Thus, the EU and U.S. cereal sectors as currently formulated are highly dependent on demand from industrial livestock production, while the latter's survival hinges on the supply of plentiful, cheap, subsidised cereals. So, we have the anomaly of a subsidised intensive crop sector that erodes soil quality and biodiversity and pollutes water that would not need to be intensive but for the fact that it must feed industrial animal production which in turn contributes to unhealthy diets and antimicrobial resistance. This is a vicious circle of mutually reinforcing damage.

## Changing food system narratives

We urgently need to change the narrative about food system change and the global economy's logic of producing as much as cheaply as possible. We need narratives that speak to the need for action to save all our futures; to bring us back from the brink of the climate, health and nature crises that we face.

Globally, our existing dominant narrative about change is about loss, whether that be in terms of profit, influence or power, with resistance and defence of business as usual being the dominant response. Current food narratives impede change, including:

- **The myth that we need to produce huge amounts of extra food:** We are told that food production must increase by 60-70% to feed the growing world population and accordingly that further industrialisation of livestock production is essential. But we already produce much more food than is needed to feed the growing world population, which is expected to reach 9.8 billion by 2050.[83] The problem is that around 60% of this food is lost or wasted through post-harvest losses, by being discarded by consumers or retailers, and through overconsumption beyond one's nutritional needs.[84] Crucially, huge amounts of human-edible cereals and soy are wasted by being fed to farm animals who convert them very inefficiently into meat and milk.[85] If all the above forms of food loss and

waste were halved, an extra 3.55 billion people could be fed.[86] [87] This is more than the anticipated increase of 2.2 billion in world population by 2050.[88]

- **The myth that industrial agriculture is efficient:** Some argue that we can make the industrial model more efficient, for example by more precise use of pesticides and fertilisers. However, industrial crop production is innately damaging to natural resources. Similarly, with its poor conversion of cereals and soy to meat and milk, industrial animal agriculture is inherently inefficient. Claiming these systems can be made more efficient or sustainable is a verbal sleight of hand; they can simply be made less inefficient and less damaging.

- **The myth that industrial agriculture provides cheap food:** We are also told industrial agriculture gives us cheap food. Industrially produced meat and milk are indeed cheap at the supermarket checkout. But the low price of these products is achieved only by an economic sleight of hand. We have devised a distorting economics which takes account of some costs such as housing and feeding animals but ignores others including the detrimental impact of industrial agriculture on the environment and health. This problem has been recognised by the FAO which has said: "In many countries there is a worrying disconnect between the retail price of food and the true cost of its production. Consequently, food produced at great environmental cost in the form of greenhouse gas emissions, water pollution, air pollution, and habitat destruction, can appear to be cheaper than more sustainably produced alternatives."[89] The negative externalities of our food system are immense. A report by the Food and Land Use Coalition estimated them to be almost US$12 trillion a year, rising to $16 trillion by 2050.[90]

## Who are the key types of stakeholders that need to work together to make the components work?

Achieving food system transformation towards healthy diets produced from humane and regenerative farming methods will require collaboration between many public and private stakeholders including:

- policy shapers and decision makers
- investors, funders and financial institutions including World Bank, IFC, EBRD
- national governments and regional, local government organisations
- IGOs and key UN organisations including, FAO, WHO, UNCCD, UNEP
- farmers/producers and their representative organisations
- business leaders, corporates, the food industry
- innovators and technologists
- academics in relevant fields including agriculture, animal welfare, animal sentience, change management, climate change, conservation, development, environment, health, human rights, nutrition, regenerative culture, regenerative agriculture, regenerative leadership and sustainability
- influential professional groups including veterinarians, economists, lawyers, agriculturalists, consumer organisations, health professionals
- civil society organisations working in relevant spheres including agriculture, animal welfare, climate change, conservation, development, environment, farming, food, health, human rights, regenerative business and sustainability.
- religious leaders
- indigenous leaders and organisations
- think tanks and thought leaders
- journalists and other media

Bringing cross sector stakeholders together to work towards any kind of change is challenging. We will need to build capacity in the system to facilitate the process of change - paying attention to how we organise stakeholders to come together and the practices and processes we use to do this. As Deputy Secretary General, Amina Mohammed highlighted in her debrief on the Pre-Summit "Dialogues have also clearly shown that

solutions and actions must be tailored to local and regional realities".

## Why is the cluster/its components actionable? Which named stakeholders (i.e., member states, agencies, donors, businesses, civil society groups) are enthusiastic about it?

The cluster is actionable because continuing with industrial agriculture will erode our future ability to provide sufficient food. The FAO has said that in its drive for high yields, intensive agriculture can undermine the key factors (e.g. soils, biodiversity and water) on which farming depends and thus "food production is seriously affected, the result being a vicious downward spiral".[91] In contrast to this, studies show that regenerative agriculture can improve water use efficiency, enhance biodiversity, boost soil quality and reduce pesticide use, while in the developing world it can deliver substantial productivity gains in both crops and livestock.[92] [93] [94] [95]

A move to regenerative agriculture, which often involves mixed crop-livestock production, is supported by many major environmental and animal welfare organisations. The need for such a move is gradually being recognised by financial institutions. For example, the Bank of America states: "Meat consumption rising unabated, but animal protein is particularly emission heavy relative to plant-based options. About 36% of global crop calories go to feed animals (67% in the US) but 100 calories of grain produce just 12 calories of chicken or 3 calories worth of beef". The Bank adds: "High rate of deforestation: 83% of agricultural land is used for livestock and growing feedstock for livestock. In contrast, livestock only contributes 18% of caloric supply for global consumption." [96] Crédit Suisse's report *Alternative Proteins* focuses on Asian consumers; it states that "Alternative proteins have the potential to address rising environmental, health and animal welfare concerns" connected with the livestock sector.[97]

The *Alliance for Food Sovereignty in Africa* states: "We need a complete transformation of our food systems. Agroecology is a people-centred system of sustainable agriculture, combining indigenous knowledge with cutting edge science, making the best use of nature to create healthy communities, and empowering a social movement that resists the corporatization of agriculture."[98]

At the Agroecology Session on 26 July 2021 at the UNFSS Pre-summit representatives from or speaking on behalf of the following countries spoke in favour of agroecology: Senegal, France, Angola, Mexico, and Sri Lanka.

The EU is supportive of a move to more sustainable agriculture. Its *Farm to Fork Strategy* aims to reduce the use of chemical pesticides by 50% by 2030, the use of chemical fertilisers by at least 20% by 2030, and sales of antimicrobials by 50% by 2030. The *Strategy* also has the objective of at least 25% of the EU's agricultural land being under organic farming by 2030.

## Contributions to Goals of All Action Tracks

**Action Track #1: Ensure access to safe and nutritious food for all**
The aim of the Solution Cluster is to focus the future of the food system on provision of affordable, healthy and sustainable diets for all produced from humane and regenerative farming practices. Consumption of animal-source foods exceeds healthy and sustainable levels in some countries and falls short in others. The solution lies in more equitable distribution of global production and consumption levels within planetary boundaries. [99] [100] This would enable increased consumption of animal-sourced foods in some countries and regions and substantial reductions amongst high-consuming populations. [101] [102] [103] [104] Issues of affordability[105] will be addressed by the cluster as will the worrying disconnect between the retail price of food and the true cost of its production in terms of harms to the environment and human health amongst others. [106] [107]

**Action Track #2: Shift to sustainable consumption patterns**
The Solution Cluster focus here is on aligning production of food to provision of healthy and sustainable diets. Resizing of the livestock industry and its reorientation to regenerative practices is proposed as part of this in view of the scientific evidence base showing that reduction in global consumption of meat and dairy is needed.

**Action Track #3: Boost nature-positive production**
The Solutions Cluster components for transformation here include shifting food systems towards nature-positive farming methods as outlined above.

**Action Track #4: Advance equitable livelihoods**
The former Director-General of the FAO highlighted the danger of small-scale livestock farmers being "pushed aside by expanding large capital-intensive operations."[108] The cluster's components include safeguarding and supporting smallholder farmers including in the Global South. Shifting livestock production to regenerative practices offers potential for improving livelihoods and working conditions with a focus on 'less and better' animal source foods as part of healthy and sustainable diets with economic systems adjusted to support provision of such foods. The Solutions Cluster encourages governments to include just transition related commitments in their national climate action plans detailing actions to be taken to mitigate climate change.[109] Just Transition approaches would address inequality and vulnerability (including with regard to farmers, workers, people's access to food); map the different actors (including those that are marginalised) and bring them to the table to develop alternatives that work for those communities and the climate; provide support (including training and capacity building) to make the transition in a socially just way, that revives local towns and connects them with rural areas, and includes reforming of subsidies.

**Action Track #5: Build resilience to vulnerabilities, shocks and stress**
Regenerative, agroecological food systems are inherently more resilient than industrial food systems. Industrial animal agriculture is dependent on routine use of antimicrobials to prevent the diseases that arise when animals are kept in poor conditions.[110] [111] The stressful, crowded conditions of industrial agriculture contribute to the emergence, spread and amplification of pathogens. [112] This leads to antimicrobial resistance in animals which can then be transferred to people. Additionally, intensively reared animals are selectively bred to have nearly identical genomes and act as vast replication vessels for some viruses.[113] To prevent future pandemics[114] and safeguard the future efficacy of antibiotics, this Solution Cluster proposes moving to 'health-oriented' systems within a 'One health, One welfare' framework for rearing animals[115].

## Key sources of evidence to support cluster

The solutions are proposed in the context of a scientific evidence-base showing that a significant reduction in global consumption and production of meat and dairy is needed if we are to achieve the Sustainable Development Goals and to meet the Paris climate targets,[116] [117] [118] [119] to reduce the environmental harms and overuse of natural resources stemming from current livestock production,[120] to lower the incidence of non-communicable disease,[121] and to minimise the use of antimicrobials[122] and the risk of the emergence of zoonotic diseases.[123] Throughout this paper we refer to the scientific evidence that guides our arguments and proposed solutions.

## Alignment of cluster with other related initiatives

The components and recommendations of this cluster align with key themes and game-changing solutions that have emerged via the Action Tracks during the UN Food Systems Summit preparations. These include, for example, One Health, shifting to non-animal-sourced meat alternatives, transitioning to regenerative, agroecological farming, redirection of subsidies towards regenerative farming and reducing demand for industrially produced meat. They are also relevant to emerging coalition themes highlighted by Deputy Secretary General Amina Mohammed highlighted in her debrief on the Pre-Summit, including:

- Action for Nutrition and Zero Hunger
- School Meals
- Food Loss and Waste
- Agroecology and Sustainable Livestock and Agriculture Systems
- Aquatic and Blue Foods
- Resilience

## Cluster support for women's empowerment, gender equity, and youth engagement

Regenerative, agroecological systems are well-suited to and already involve women and youth. A key focus of the Solution Cluster will be to put back pride into farming and land stewardship as a means of working in harmony with nature for the benefit of people, animals and the planet. It is essential to keep youth interested and incentivised to take up farming, in the face of increasing urbanisation and the critical narratives of environmental degradation from the current food system. Shorter, local, sustainable supply chains with fair wages and visible environmental benefits will help put pride back in the task of feeding people and protecting the planet. Several sustainable agriculture programmes put a strong emphasis on women's empowerment. For example, Sustainable Agriculture Tanzania (SAT) teaches farmers how to escape the poverty trap by the adoption of agroecological methods. 60% of the farmers SAT worked with in 2019 were women. SAT explains that the *Dodoma's Women in Agriculture and Business Initiative* aims at the empowerment of women in agriculture as well as entrepreneurship.

## How much will the cluster components cost (with explanation)? And how will they be financed?

Huge costs will be involved in failing to address the detrimental health and environmental impacts of industrial livestock production - and the excess consumption of meat that it has engendered in the developed world and certain emerging economies. A 2020 FAO report compares current dietary patterns with four healthy alternatives each including less meat and dairy than current diets.[124] It states that in 2030 "any of the four alternative healthy diet patterns worldwide would reduce projected diet-related GHG emission by 41–74%". The report adds that changing from current diets to any of the four alternative healthy diets would reduce global diet-related health costs by 2030 by up to a staggering 95%.

The cost of changing from industrial to sustainable livestock systems will vary largely depending on the specifics of the new system. However, provided that an adequate transition period is given, the costs are likely to be modest as industrial systems are dependent on costly inputs of cereals and soy as feed; feed accounts for around 60% of the cost of raising pigs and poultry in industrial systems.[125] In contrast to this, sustainable livestock systems have much lower feed costs as animals are primarily fed on grass or other vegetation, crop residues, by-products such as brewers' grains, and unavoidable food waste such as bakery products, fruit and vegetables that are past their sell-by date, or are not suitable for human consumption. All of these are much less costly than cereals and soy.

It should be borne in mind that on a business-as-usual basis a 7–10% decline in livestock is expected, with associated economic losses between $9.7 and $12.6 billion solely due to climate change.[126]

Sustainable livestock systems also:

- involve substantially lower use of costly antimicrobials than industrial systems
- often entail reduced housing costs as items such as cages, crates, and mechanical ventilation, which are common in industrial systems, are expensive.

Improved animal welfare often produces economic benefits. For example, animals with higher welfare may be healthier resulting in lower veterinary costs and reduced disease and mortality as well as in some instances better growth rates and feed conversion. Gentler handling of animals at markets and during transport and slaughter may involve few costs other than training but may bring better food quality and substantial economic benefits in the form of reduced bruising and carcase downgrades.

Improved welfare in dairy cows produces economic benefits. Lameness and mastitis are common painful problems in dairy cows. Lame cows and those with mastitis produce less milk and incur costs for treatment and veterinary medicines. Minimising lameness and mastitis delivers considerable economic benefits.

## What kind of impact can be expected over what time frame?

Many of the changes advocated by this paper could be achieved, or be well underway, by 2030. If they are not, several of the SDGs, the Paris climate targets, and global biodiversity targets will be out of reach.

A move to nature-positive farming generally does not entail the huge capital expenditures often required by industrial livestock production. The costs of moving to regenerative and agroecological farming should be supported by repurposing existing subsidies.

Diets in the developed world could be transformed quite rapidly if the public understood the need for change. And there is clear evidence that many do recognise the need for far-reaching changes. An IPSOS Mori survey published in August 2021 reported that 83% of people in G20 countries are willing to do more to become better "planetary stewards" and protect and regenerate the global commons. People in developing economies showed greater willingness to do more to protect nature and climate than those in advanced economies.[127]

The global response to Covid has shown that far-reaching changes in lifestyle can be rapidly achieved in the face of an emergency and threat to life. The world now needs to recognise that the threats posed by climate change, biodiversity loss, soil degradation, water pollution and antimicrobial resistance comprise a clear and present danger to humanity and the planet. If this is recognised, we could swiftly move to establishing new and genuinely sustainable, healthy and humane food systems.

Ends

---

[1] Springmann, M., Clark, M., Mason-D'Croz, D. *et al. Options for keeping the food system within environmental limits*. (Nature **562,** 2018) 519–525 https://doi.org/10.1038/s41586-018-0594-0

[2] Willett *et al,. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems.* (The Lancet, 2019) http://dx.doi.org/10.1016/S0140-6736(18)31788-4

[3] Clark *et al,. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets.* (Science 370, 2020) 705–708

[4] Springmann M., Godfray H.C., Rayner M. & Scarborough P. *Analysis and valuation of the health and climate change cobenefits of dietary change.* (PNAS, vol. 113, no. 15, 2016) 4146–4151

[5] Papier, K., Knuppel, A., Syam, N., Jebb, S.A. & Key, T.J. *Meat consumption and risk of ischemic heart disease: A systematic review and metaanalysis*. (Critical Reviews in Food Science and Nutrition, 2021) DOI: 10.1080/10408398.2021.1949575

[6] Food and Agriculture Organisation of the United Nations. *Agroecology to reverse soil degradation and achieve food security* (Rome, 2015) http://www.fao.org/3/a-i4803e.pdf

[7] Ritchie, H. and Roser, M. *Land Use* (Our World in Data, September 2019) https://ourworldindata.org/land-use

[8] Food and Agriculture Organisation of the United Nations. *Tackling climate change through livestock* (2014)

[9] Pradhan *et a*. *Embodied crop calories in animal products*. (Environ. Res. Lett. 8, 2013) 044044

[10] Global Land Outlook. (UN Convention to Combat Desertification, 2017).

[11] Nellemann *et al*. *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. (United Nations Environment Programme, GRID-Arendal, 2009) www.unep.org/pdf/foodcrisis_lores.pdf

[12] Lundqvist, J., de Fraiture, C. Molden, D. *Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain*. (SIWI Policy Brief, 2008) http://www.siwi.org/documents/Resources/Policy_Briefs/PB_From_Filed_to_Fork_2008.pdf

[13] Nellemann *et al*. *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. (United Nations Environment Programme, GRID-Arendal, 2009), www.unep.org/pdf/foodcrisis_lores.pdf

[14] Cassidy ES, West PC, Gerber JS and Foley J A ( Environmental Research Letters 8: 1-8, 2013) Redefining agricultural yields: from tonnes to people nourished per hectare.

[15] Global Biodiversity Outlook 5. (UN Environment Programme and the Convention on Biological Diversity, 2020)

[16] Global Land Outlook. (UN Convention to Combat Desertification, 2017).

[17] Edmondson *et al. Urban cultivation in allotments maintains soil qualities adversely affected by conventional agriculture.* (Journal of Applied Ecology, 2014), 51, 880–889
[18] Tsiafouli *et al. Intensive agriculture reduces soil biodiversity across Europe*. (Global Change Biology: 21, 2015) p973–985
[19] Mekonnen, M. and Hoekstra, A. *A global assessment of the water footprint of farm animal products*. (Ecosystems, 2012) DOI: 10.1007/s10021-011-9517-8
[20] Lelieveld *et al*. *The contribution of outdoor air pollution sources to premature mortality on a global scale*. (Nature, Vol 525, 2015).
[21] Ritchie, H. and Roser, M. *Soy* (Our World in Data, 2021) https://ourworldindata.org/soy Accessed 25 July 2021
[22] Boeckel *et al. Global trends in antimicrobial resistance in animals in low- and middle-income countries*. (Science 365, 2019) 1266
[23] Friel S., Dangour A.D., Garnett T., Lock K., Chalabi Z., Roberts I., Butler A., Butler C.D. Waage J., McMichael A.J. and Haines A. *Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture*. (The Lancet, Health and Climate Change 4, Published online November 25, 2009) DOI:10.1016/S0140-6736(09)61753-0
[24] Aston, L. M., Smith, J. N. and Powles, J. W. *Impact of a reduced red and processed meat dietary pattern on disease risks and greenhouse gas emissions in the UK: a modelling study*. (BMJ, Open Vol 2, Issue 5, 2012) http://bmjopen.bmj.com/content/2/5/e001072.full.pdf+html
[25] Anand, S. *et al.*. *Food Consumption and its Impact on Cardiovascular Disease: Importance of Solutions Focused on the Globalized Food System*. (Journal of the American College of Cardiology, 66, no 14, 2015)
[26] Bouvard *et* al. *Carcinogenicity of consumption of red and processed meat*. (The Lancet Oncology, 2015) http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045(15)00444-1/abstract
[27] Bechthold, A., Boeing, H., Schwedhelm, C., Hoffmann, G., Knüppel, S., Iqbal, K., De Henauw, S., Michels, N., Devleesschauwer, B., Schlesinger, S. & Schwingshackl, L. *Food groups and risk of coronary heart disease, stroke and heart failure: A systematic review and dose-response meta-analysis of prospective studies*. (Critical Reviews in Food Science and Nutrition, 59:7, 2019) 1071-1090, https://www.tandfonline.com/action/showCitFormats?doi=10.1080%2F10408398.2017.1392288
[28] Schwingshackl, L. et al. *Food groups and risk of colorectal cancer*. (International Journal of Cancer, 2017) https://onlinelibrary.wiley.com/doi/10.1002/ijc.31198,
[29] Schwingshackl, L., Hoffmann, G., Lampousi, A. M., *et al. Food groups and risk of type 2 diabetes mellitus: a systematic review and meta-analysis of prospective studies*. (Eur J Epidemiol **32,** 2017) 363–375. https://link.springer.com/article/10.1007%2Fs10654-017-0246-y
[30] Schwingshackl L, Schwedhelm C, Hoffmann G, Lampousi A. M., *et al. Food groups and risk of all-cause mortality: a systematic review and meta-analysis of prospective studies*. (Am J Clin Nutr. 2017) 105(6):1462-1473. https://pubmed.ncbi.nlm.nih.gov/28446499/
[31] Lancet Countdown. *Tracking Progress on Health and Climate Change – Diet and Health Co-Benefits*. (The Lancet, 2020) https://www.lancetcountdown.org/data-platform/mitigation-actions-and-health-co-benefits/3-5-food-agriculture-and-health/3-5-2-awaiting-data-diet-and-health-co-benefits
[32] Springmann, M. et al (The Lancet, 2018) Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. https://doi.org/10.1016/S2542-5196(18)30206-7

[33] Springman M. et al. (BMJ 2020;370:m2322) The healthiness and sustainability of national and global food based dietary guidelines: modelling study.

[34] Springmann, M., Mason-D'Croz, D., Robinson, S., Wiebe, K., Godfray, H. C. J., Rayner, M., Scarborough, P., *Health-motivated taxes on red and processed meat: A modelling study on optimal tax levels and associated health impacts*. (PLOS ONE 13(11), 2018) https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0204139
[35] Springmann, M., Spajic, L., Clark, M. A., Poore, J., Herforth, A., Webb, P. et al. *The healthiness and sustainability of national and global food based dietary guidelines: modelling study*. (BMJ 2020) 370 https://www.bmj.com/content/370/bmj.m2322
[36] Springmann, M., Wiebe, K., Mason-D'Croz, D., Sulser, T.B., Rayner, M., Scarborough, P. *Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail.* (The Lancet Planetary Health, 2018) https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(18)30206-7/fulltext
[37] Gura, S. *Industrial livestock production and its impact on smallholders in developing countries*. (Consultancy report to the League for Pastoral Peoples and Endogenous Livestock Development, Germany, 2008). http://re.indiaenvironmentportal.org.in/files/gura_ind_livestock_prod.pdf
[38] Participants at the "Livestock Diversity Forum". *Wilderswil declaration on livestock diversity*. (6 September 2007) http://www.ukabc.org/wilderswil.pdf
[39] Ripple *et al. World scientists' warning of a climate emergency*. (Published in Bioscience, 2019)

[40] The Pasture Fed Livestock Association (Pasture for Life website) https://www.pastureforlife.org/
[41] Gura, S. *Industrial livestock production and its impact on smallholders in developing countries*. (Consultancy report to the League for Pastoral Peoples and Endogenous Livestock Development, Germany, 2008). http://re.indiaenvironmentportal.org.in/files/gura_ind_livestock_prod.pdf
[42] Participants at the "Livestock Diversity Forum". *Wilderswil declaration on livestock diversity*. (6 September 2007) http://www.ukabc.org/wilderswil.pdf
[43] Saget, C., Vogt-Schilb, A. and Luu, T. *Jobs in a Net-Zero Emissions Future in Latin America and the Caribbean*. (Inter-American Development Bank (IDB) and International Labour Organization (ILO), Washington D.C. and Geneva, 2020) https://www.ilo.org/global/docs/WCMS_752069/lang–en/index.htm
[44] Cook, E.A.J., de Glanville, W.A., Thomas, L.F. *et al. Working conditions and public health risks in slaughterhouses in western Kenya*. (BMC Public Health **17,** 14, 2017). https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-016-3923-y
[45] Leibler, J.H., Perry, M.J. *Self-reported occupational injuries among industrial beef slaughterhouse workers in the Midwestern United States*. (J Occup Environ Hyg., 14(1):23-30, Jan 2017). https://pubmed.ncbi.nlm.nih.gov/27715500/
[46] Reis, D. C., Ramos, E., Reis, P. F., Hembecker, P. K., Gontijo, L. A., Moro, A. R. P. *Assessment of Risk Factors of Upper-limb Musculoskeletal Disorders in Poultry Slaughterhouse.* (Procedia Manufacturing Vol 3, 2015) Pages 4309-4314 https://www.sciencedirect.com/science/article/pii/S2351978915004242
[47] Mellor, D. *Updating Animal Welfare Thinking: Moving beyond the "Five Freedoms" towards "A Life Worth Living"*. (Animals 6, 21. 2016)
[48] Food and Agriculture Organisation of the United Nations. *Animal Welfare L Archives*. https://listserv.fao.org/scripts/wa-fao.exe?A0=FAO-ANIMALWELFARE-L&S=b Accessed 3 February 2021.
[49] Review on Antimicrobial Resistance, Chaired by Jim O'Neill. *Antimicrobials in Agriculture and the Environment: Reducing Unnecessary Use and Waste*. (The Wellcome Trust and UK Department of Health, December 2015) http://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf
[50] Food and Agriculture Organisation of the United Nations. *FAO calls for international action on antimicrobial resistance*. (10 February 2016) http://www.fao.org/news/story/en/item/382636/icode/ Accessed 20 January 2017
[51] Boeckel *et al. Global trends in antimicrobial resistance in animals in low- and middle-income countries*. (Science 365, 1266, 2019)
[52] EMA (European Medicines Agency) and EFSA (European Food Safety Authority). *EMA and EFSA Joint Scientific Opinion on measures to reduce the need to use antimicrobial agents in animal husbandry in the European Union, and the resulting impacts on food safety (RONAFA)*. (EFSA Journal, 15(1) :4666, 2017) EMA/CVMP/570771/2015
[53] United Nations Environment Programme. *Coronaviruses: are they here to stay?* (United Nations Environment Programme, 2020). Available at: https://www.unep. org/news-and-stories/story/coronaviruses-are-they-here-stay
[54] For a broad assessment of zoonotic disease risk, see: Jones, B. A. et al. *Zoonosis emergence linked to agricultural intensification and environmental change*. (Proceedings of the National Academy of Sciences of the United States of America, 2013). Available at: https:// doi.org/10.1073/pnas.1208059110
For low genetic diversity enabling rapid viral spread in factory farms. For cross-species pandemic-capable infection: Ali, A., Khatri, M. et al. (2012). *Identification of swine H1N2/pandemic H1N1 reassortant influenza virus in pigs, United States*. (Veterinary Microbiology, 2012). Available at: https://doi.org/10.1016/j.vetmic.2012.02.014;
For related poultry data: Rozins, C. and Day, T. *The industrialization of farming may be driving virulence evolution*. (Evolutionary applications, 10(2), 2016) 189–198. Available at: https://doi.org/10.1111/eva.12442.
For agricultural intensification's effect on pandemic risk: Willyard, C. *Flu on the farm*. (Nature, 2019) Available at: https://www.nature.com/articles/d41586-019- 02757-4.
Sources all recently cited in *National Food Strategy*, (Independent Review, July 2021) available at: https://www.nationalfoodstrategy.org/
[55] Review on Antimicrobial Resistance. *Tackling Drug-Resistant Infections Globally Final Report and Recommendation*. (Review on Antimicrobial Resistance, 2016). Available at: https://amr-review.org/sites/ default/files/160518_Final%20paper_with%20cover.pdf
[56] Pinillos. R.G., Appleby. M.C., Manteca, X., Scott-Park, F., Smith, C., Velarde, A. *One Welfare - a platform for improving human and animal welfare*. (Vet Rec. 179(16):412-413, 2016) doi: 10.1136/vr. i5470. PMID: 27770094.
[57] WHO. *One Health*. (World Health Organisation, 2017) https://www.who.int/news-room/q-a-detail/one-health.
[58] Clark *et al. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets*. (Science 370, 2020) 705–708
[59] Springmann *et al. Options for keeping the food system within environmental limits*. (Nature, 2018) https://www.nature.com/articles/s41586-018-0594-0
[60] Springmann, M., Spajic, L., Clark, M. A., Poore, J., Herforth, A., Webb, P. et al. *The healthiness and sustainability of national and global food based dietary guidelines: modelling study* (BMJ, 370 :m2322, 2020) doi:10.1136/bmj.m2322 https://www.bmj.com/content/370/bmj.m2322

[61] De Schutter, O. *Towards a Common Food Policy for the European Union*. (iPES Food, 2019)
[62] Hamilton, I., Kennard, H., McGushin, A., Höglund-Isaksson, L., Kiesewetter, G., Lott, M., Milner, J., Purohit, P., Rafaj, P., Sharma, R., Springmann, M., Woodcock, J., Watts, N. *The public health implications of the Paris Agreement: a modelling study*. (The Lancet Planetary Health Vol 5, February 2021) https://www.thelancet.com/pdfs/journals/lanplh/PIIS2542-5196(20)30249-7.pdf
[63] Springmann, M., Clark, M., Mason-D'Croz, D. *et al. Options for keeping the food system within environmental limits*. (Nature **562,** 2018**)** 519–525 https://www.nature.com/articles/s41586-018-0594-0
[64] The City of Copenhagen website. *Copenhagen's organic food revolution.* (23rd May 2016) https://international.kk.dk/nyheder/copenhagens-organic-food-revolution, accessed 20 September 2019
[65] The City of Copenhagen website. *Op. Cit.*
[66] Springmann, M. *Valuation of the health and climate-change benefits of healthy diets. Background paper for The State of Food Security and Nutrition in the World 2020*. (FAO 20-03, Rome, 2020)
[67] De Schutter, O. *Report of the Special Rapporteur on the right to food*. (United Nations General Assembly, Human Rights Council, Nineteenth session, 26 December 2011) A/HRC/19/59 http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session19/A-HRC-19-59_en.pdf
[68] FAO, UNDP and UNEP. 2021. A multi-billion-dollar opportunity – Repurposing agricultural support to transform food systems. Rome, FAO. https://doi.org/10.4060/cb6562en
[69] Willett *et al*. *Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems.* (The Lancet, 2019) http://dx.doi.org/10.1016/S0140-6736(18)31788-4
[70] Swinburn *et* al. *The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report* (The Lancet, 2019) http://dx.doi.org/10.1016/S0140-6736(18)32822-8
[71] Nature editorial, (Nature, Vol 574, 17 October 2019)
[72] Battini, N., Parry, I. & Wingender, P. *IMF Working Paper. Climate Mitigation Policy in Denmark: A Prototype for Other Countries.* (International Monetary Fund, 2020)
[73] FAIRR (an initiative of the Jeremy Coller Foundation). See: https://www.fairr.org/about
[74] Freund, F., Springmann, M. *Policy analysis indicates health-sensitive trade and subsidy reforms are needed in the UK to avoid adverse dietary health impacts post-Brexit*. (Nat Food **2,** 2021) 502–508. https://doi.org/10.1038/s43016-021-00306-9
[75] Pradhan *et al*. *Embodied crop calories in animal products*. (Environ. Res. Lett. 8, 2013) 044044
[76] Global Land Outlook. (UN Convention to Combat Desertification, 2017).
[77] Lundqvist, J., de Fraiture, C. Molden, D. *Saving Water: From Field to Fork – Curbing Losses and Wastage in the Food Chain*. SIWI Policy Brief. (SIWI, 2008) http://www.siwi.org/documents/Resources/Policy_Briefs/PB_From_Filed_to_Fork_2008.pdf
[78] Nellemann, C., MacDevette, M., Manders, et al. *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. (United Nations Environment Programme, GRID-Arendal, 2009) www.unep.org/pdf/foodcrisis_lores.pdf
[79] Berners-Lee *et al*. *Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation*. (Elem Sci Anth, 6: 52, 2018)
[80] Tuomisto, H. & Mattos, M. J. *Life cycle assessment of cultured meat production*. (2010) https://www.researchgate.net/publication/215666764_Life_cycle_assessment_of_cultured_meat_production#:~:text=Cultured%20meat%20is%20produced%20in%20vitro%20by%20using%20tissue%20engineering%20techniques.&text=Life%20cycle%20assessment%20(LCA)%20research,source%20for%20muscle%20cell%20growth
[81] Tubb, C. & Seba, T. *Rethinking Food and Agriculture 2020-2030: The Second Domestication of Plants and Animals, the Disruption of the Cow, and the Collapse of Industrial Livestock Farming*. (RethinkX: San Francisco, 2019) https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/5d7fe0e83d119516bfc0017e/1568661791363/RethinkX+Food+and+Agriculture+Report.pdf
[82] Alliance for Food Sovereignty in Africa (AFSA). *Advocating for agroecology in policy and practice.* (afsafrica.org) https://afsafrica.org/advocating-for-agroecology-in-policy-and-practice/ Accessed 31 January 2021
[83] Food and Agriculture Organisation of the United Nations, Calculations based on FAOSTAT, *Production, crops*, http://www.fao.org/faostat/en/#data/;
FAOSTAT, *Production, Crops processed* http://www.fao.org/faostat/en/#data/QD;
FAOSTAT, *Food supply, crops primary equivalent*, http://www.fao.org/faostat/en/#data/CC and 2018 FAOSTAT figures for *crop production*: FAOSTAT, *Production, crops*, http://www.fao.org/faostat/en/#data/;
FAOSTAT, *Production, Crops processed* http://www.fao.org/faostat/en/#data/QD
[84] Alexander P *et al*. *Losses, inefficiencies and waste in the global food system*. (Agricultural Systems 153, 2017) 190–200
[85] Nellemann, C., MacDevette, M., Manders, et al. *The environmental food crisis – The environment's role in averting future food crises*. A UNEP rapid response assessment. (United Nations Environment Programme, GRID-Arendal, 2009) www.unep.org/pdf/foodcrisis_lores.pdf
[86] *Ibid*

[87] Cassidy E.M *et al*, 2013. *Redefining agricultural yields: from tonnes to people nourished per hectare*. (University of Minnesota. Environ. Res. Lett. 8, 2013) 034015
[88] UN Department of Economic and Social Affairs. *World population projected to reach 9.8 billion in 2050, and 11.2 billion in 2100* (UN DESA, New York, 21 June 2017) https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html Accessed 6 September 2017
[89] Food and Agriculture Organisation of the United Nations. *Natural capital impacts in agriculture. (2015)*
[90] Food and Land Use Coalition. *Growing better.* (2019)
[91] FAO, ITPS, GSBI, SCBD and EC. *State of knowledge of soil biodiversity - Status, challenges and potentialities, Report 2020*. (FAO, Rome, 2020) https://doi.org/10.4060/cb1928en
[92] Jules Pretty et al., *Resource-conserving agriculture increases yields in developing countries*. (Environmental Science and Technology, 40:4, 2006) 1114−1119
[93] Jules Pretty, Camilla Toulmin & Stella Williams. *Sustainable intensification in African agriculture*. (International Journal of Agricultural Sustainability, 9:1, 2011) 5-24
[94] Sustainable Agriculture Tanzania. https://kilimo.org/ Accessed 12 August 2021
[95] Broom, D.M., Galindo, F.A. and Murgueitio, E. *Sustainable, efficient livestock production with high biodiversity and good welfare for animals*. (Proc. Roy.Soc. B. 280, 2013, 2025)
[96] Bank of America. *Emission Impossible? Global Climate Change Primer*. (Readkong.com, 2020) https://www.readkong.com/page/emission-impossible-global-climate-change-primer-9063655
[97] Crédit Suisse. *Alternative Proteins: Exploring the Asian appetite and conservation potential*. (2020)
[98] Alliance for Food Sovereignty in Africa (AFSA). *Advocating for agroecology in policy and practice.* (afsafrica.org) https://afsafrica.org/advocating-for-agroecology-in-policy-and-practice/ Accessed 31 January 2021
[99] Willett *et al*. *Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems*. (The Lancet, 2019) https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31788-4/fulltext
[100] EAT. *Diets for a better future*. (eatforum.org, 2020) https://eatforum.org/content/uploads/2020/07/Diets-for-a-Better-Future_G20_National-Dietary-Guidelines.pdf
[101] Willett *et al*. *Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems*. (The Lancet, 2019) http://dx.doi.org/10.1016/S0140-6736(18)31788-4
[102] Clark *et al*. *Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets*. (Science 370, 2020) 705–708
[103] Springmann M., Godfray H.C., Rayner M. & Scarborough P. *Analysis and valuation of the health and climate change cobenefits of dietary change.* (PNAS vol. 113 no. 15, 2016) 4146–4151
[104] Papier, K., Knuppel, A., Syam, N., Jebb, S. A. & Key, T. J. *Meat consumption and risk of ischemic heart disease: A systematic review and metaanalysis*. (Critical Reviews in Food Science and Nutrition, 2021) DOI: 10.1080/10408398.2021.1949575
[105] Hirvonen, K. et al. *Affordability of the EAT–Lancet reference diet: a global analysis*. (The Lancet, 2019) https://doi.org/10.1016/S2214-109X(19)30447-4
[106] Food and Agriculture Organisation of the United Nations. *Natural capital impacts in agriculture*. (2015) http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Natural_Capital_Impacts_in_Agriculture_final.pdf
[107] Battini, N., Parry, I. & Wingender, P. *IMF Working Paper. Climate Mitigation Policy in Denmark: A Prototype for Other Countries* (International Monetary Fund, 2020)
[108] Food and Agriculture Organisation of the United Nations. *More than meat: Shaping the future of livestock*. (fao.org, Rome/Berlin, 20 January 2018) http://www.fao.org/news/story/en/item/1098231/icode/ Accessed 15 July 2020
[109] United Nations Framework Convention on Climate Change. *The Paris Agreement and Nationally Determined Contributions (NDCS)*. (UNFCC) https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/nationally-determined-contributions-ndcs
[110] Review on Antimicrobial Resistance, Chaired by Jim O'Neill. *Antimicrobials in Agriculture and the Environment: Reducing Unnecessary Use and Waste*. (The Wellcome Trust and UK Department of Health, December 2015) http://amr-review.org/sites/default/files/Antimicrobials%20in%20agriculture%20and%20the%20environment%20-%20Reducing%20unnecessary%20use%20and%20waste.pdf
[111] Food and Agriculture Organisation of the United Nations. *FAO calls for international action on antimicrobial resistance*. (10 February 2016) http://www.fao.org/news/story/en/item/382636/icode/ Accessed 20 January 2017
[112] EMA (European Medicines Agency) and EFSA (European Food Safety Authority). *EMA and EFSA Joint Scientific Opinion on measures to reduce the need to use antimicrobial agents in animal husbandry in the European Union, and the resulting impacts on food safety (RONAFA*). (EFSA Journal, 15(1) :4666, 2017) [EMA/CVMP/570771/2015].

[113] United Nations Environment Programme. *Coronaviruses: are they here to stay?* (United Nations Environment Programme, 2020). Available at: https://www.unep. org/news-and-stories/story/coronaviruses-are-they-here-stay
[114] For a broad assessment of zoonotic disease risk, see: Jones, B. A. et al. *Zoonosis emergence linked to agricultural intensification and environmental change*. (Proceedings of the National Academy of Sciences of the United States of America, 2013). Available at: https:// doi.org/10.1073/pnas.1208059110
For low genetic diversity enabling rapid viral spread in factory farms. For cross-species pandemic-capable infection: Ali, A., Khatri, M. et al. (2012). *Identification of swine H1N2/pandemic H1N1 reassortant influenza virus in pigs, United States*. (Veterinary Microbiology, 2012). Available at: https://doi.org/10.1016/j.vetmic.2012.02.014;
For related poultry data: Rozins, C. and Day, T. *The industrialization of farming may be driving virulence evolution*. (Evolutionary applications, 10(2), 2016) 189–198. Available at: https://doi.org/10.1111/eva.12442.
For agricultural intensification's effect on pandemic risk: Willyard, C. *Flu on the farm*. (Nature, 2019) Available at: https://www.nature.com/articles/d41586-019- 02757-4.
Sources all recently cited in *National Food Strategy*, (Independent Review, July 2021) available at: https://www.nationalfoodstrategy.org/
[115] Review on Antimicrobial Resistance. *Tackling Drug-Resistant Infections Globally Final Report and Recommendation.* (Review on Antimicrobial Resistance, 2016) Available at: https://amr-review.org/sites/ default/files/160518_Final%20paper_with%20cover.pdf
[116] Springmann, M., Clark, M., Mason-D'Croz, D. *et al. Options for keeping the food system within environmental limits*. (Nature **562,** 2018) 519–525. https://doi.org/10.1038/s41586-018-0594-0
[117] Bajželj B., Richards K.S., Allwood J.M., Smith P., Dennis J.S., Curmi E. & Gilligan C.A. *Importance of food-demand management for climate mitigation*. (Nature Climate Change, Vol 4, October 2014) http://www.nature.com/doifinder/10.1038/nclimate2353
[118] Springmann M., Godfray H.C., Rayner M. & Scarborough P. *Analysis and valuation of the health and climate change cobenefits of dietary change.* (PNAS vol. 113 no. 15, 2016) 4146–4151
[119] Clark *et al. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets*. (Science 370, 2020) 705–708
[120] Schader, C. et al. 2015. *Impacts of feeding less food-competing feedstuffs to livestock on global food system sustainability*. (J. R. Soc. Interface 12: 2015) http://dx.doi.org/10.1098/rsif.2015.0891
[121] Willett *et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems*. (The Lancet, 2019) http://dx.doi.org/10.1016/S0140-6736(18)31788-4
[122] EMA (European Medicines Agency) and EFSA (European Food Safety Authority). *EMA and EFSA Joint Scientific Opinion on measures to reduce the need to use antimicrobial agents in animal husbandry in the European Union, and the resulting impacts on food safety (RONAFA)*. (EFSA Journal, 15(1) :4666, 2017) [EMA/CVMP/570771/2015]
[123] UNEP & ILRI. *Preventing the next pandemic*. (unep.org, 2020) https://www.unep.org/resources/report/preventing-future-zoonotic-disease-outbreaks-protecting-environment-animals-and
[124] FAO, IFAD, UNICEF, WFP and WHO. *The State of Food Security and Nutrition in the World 2020*. *Transforming food systems for affordable healthy diets*. (FAO, Rome, 2020)
[125] European Parliament Directorate General for Internal Policies. *The poultry and egg sectors: evaluation of the current market situation and future prospects.* (europarl.europa.eu, 2010) http://www.europarl.europa.eu/RegData/etudes/etudes/join/2010/438590/IPOL-AGRI_ET(2010)438590_EN.pdf
[126] Boone, R. B., Conant, R. T., Sircely, J., Thornton, P. K., Herrero, M. *Climate change impacts on selected global rangeland ecosystem services* (Wiley Online Library, 2017) https://onlinelibrary.wiley.com/doi/10.1111/gcb.13995
[127] Global Commons Alliance: A Plan for the Planet. *The Global Commons Survey.* (August 2021) https://globalcommonsalliance.org/news/global-commons-alliance/global-commons-g20-survey/ Accessed 17 August 2021