Are livestock always bad for the planet?

Rethinking the protein transition and climate change debate

PASTRES
Pastoralism, Uncertainty, Resilience

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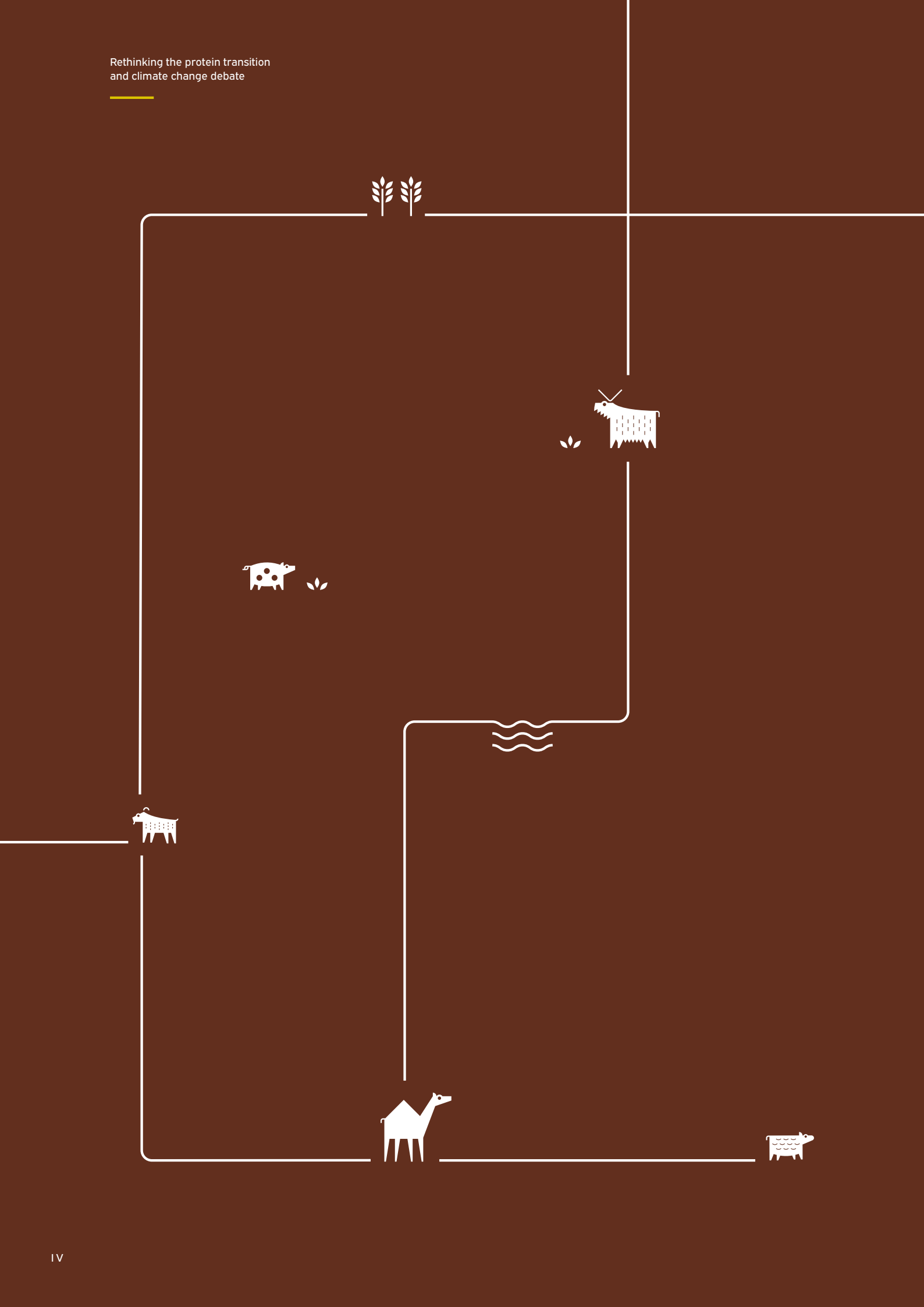
Pastoralist in Amdo Tibet. Photo: Palden Tsering



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pastoralist boy in Terrat Village, Tanzania. Photo: ILRI/Fiona Flintan

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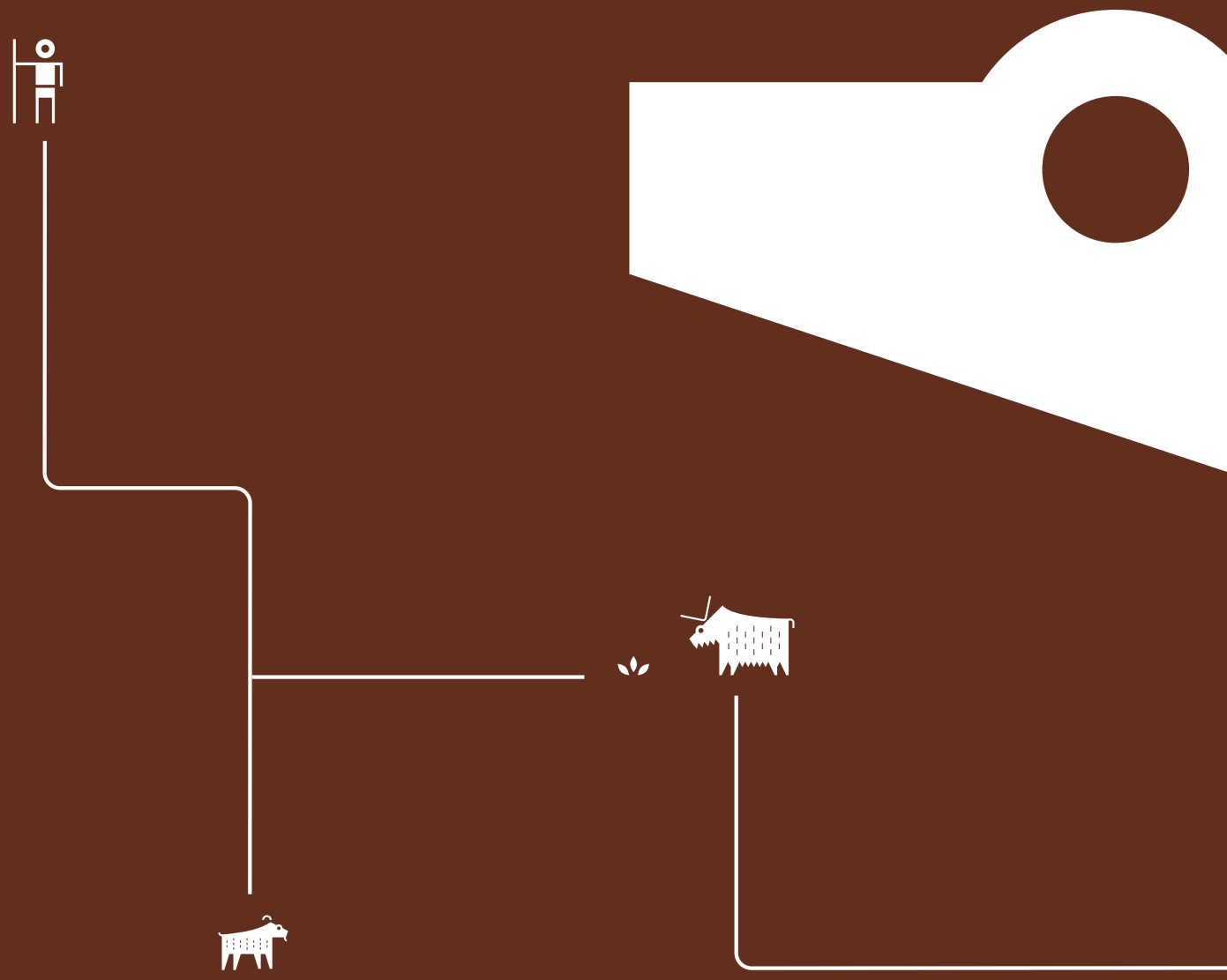
Executive summary

Are livestock always bad for the planet?

Urgent climate challenges have triggered calls for radical, widespread changes in what we eat, pushing for the drastic reduction if not elimination of animal-source foods from our diets. But high-profile debates, based on patchy evidence, are failing to differentiate between varied landscapes, environments and production methods. Relatively low-impact, extensive livestock production, such as pastoralism, is being lumped in with industrial systems in the conversation about the future of food.



The narrative that 'meat and milk are bad' because livestock production is a major greenhouse gas emitter is widespread, promoted by international agencies, campaign groups, corporations and governments. This overarching narrative has led to generalised policy prescriptions, applicable to some western diets and to some forms of livestock production. Of course, caveats are sometimes applied, but policy and media messages tend to simplify, meaning that the vast differences between industrial and extensive livestock production are often neglected in policy and campaign messages. As a result, inappropriate policies could do great damage to livelihoods, landscapes and the life chances of people reliant on extensive livestock production, including pastoralism. Such systems involve many millions of people across rangelands covering over half the world's land surface.

Where do the figures that are widely shared in the media and in policy debates come from? This report delves into the assumptions and uncertainties that are central to these influential calculations. Life cycle assessment models are frequently used, but the data are often derived from a limited set of cases, mostly from industrial systems particularly from Europe and North America. We identify 10 core assumptions and gaps in such assessments. These centre on the limitations and biases of the data; the way systems are analysed – what's included and excluded; and how baselines are defined and alternatives assessed.

For example, due to the lack of data from many parts of the world, assumptions on livestock emissions are based on studies of intensive, contained, industrial systems, with data often extrapolated to extensive livestock production. Additionally, the impact of different greenhouse gases is assessed in controversial ways. Methane, emitted in large quantities from livestock systems, has very different impacts on global warming compared to carbon dioxide, for example. Wider environmental benefits offered by extensive livestock systems to ecosystem services, landscape protection and carbon sequestration may be missed by a narrow life cycle assessment. In extensive systems, carbon cycles are complex, with much spatial and temporal variation and particular hotspots for emissions and also for carbon and nitrogen storage.

What are we comparing livestock emission figures against? If extensively grazed livestock are removed, what replaces them? Many imagine the return of a 'wild' ecosystem, but numerous studies show that wildlife and termites in 'natural' systems may produce equivalent emissions, if not more. In many settings where extensive livestock production is central to people's livelihoods, there are few land use alternatives, as crop farming and tree growing are not feasible.

A wider systems approach is therefore urgently needed for assessing livestock-related emissions in low-input, extensive systems including pastoralism, allowing for a more targeted and realistic approach to mitigation. A focus on the systems of production rather than just on the products (such as meat and milk) is essential. A systems approach would acknowledge movement across rangelands and account for the benefits to ecosystem services and potential carbon sequestration. Analyses of industrial systems equally must include the costs of cropped feed, fossil fuel intensive processing, transport, marketing and infrastructure.

Understanding extensive livestock systems therefore requires more research into how to manage emissions in rangelands, while still securing livelihoods and environmental benefits. This research must include livestock keepers who know their production systems and the possibilities of making use of rangelands sustainably.

A more balanced approach to global debates about changing diets is also required. The provision of high-density animal protein is essential for nutrition in many parts of the world, especially for poorer people and children. This cannot easily be replaced by plant-based or industrially manufactured alternatives. Low-input livestock production, including from pastoralism, is an essential provider of healthy diets. This of course contrasts with the clear need to transform diets in other places, where over-consumption of industrially produced animal-source foods creates both health and environmental problems.

Extensive livestock systems of course still remain contributors to greenhouse gas emissions and must be central to locally attuned mitigation efforts. But such multi-functional livestock systems also offer important benefits: in safeguarding the environment; reducing poverty and expanding livelihood opportunities; improving access to protein in diets; and enhancing economic development through markets and exchange. Livestock, therefore, are not always bad for the planet, and the debate on climate change and the protein transition urgently needs to become more sophisticated.

Low-impact, extensive livestock systems, including pastoralism, can show a way to the future. Ensuring that pastoralists' and smallholder livestock keepers' voices are heard is a question of climate justice. Climate policy must avoid dangerous impositions, while ensuring that currently silenced perspectives are heard in the debate. Discussions on global climate policy and debates about food systems must make sure this happens. This report offers some recommendations on how this can be done.

"The findings of assessments using Life Cycle Analyses methodologies permeate the policy response. This results in generalised mitigation packages – whether around consumption or production – that ignore extensive livestock systems."

Mongolian cowgirl. Photo: Paulo Fassina

Livestock and climate change: *The debate*

Sheep in Amdo Tibet. Photo: Palden Tsering

In recent years, the livestock sector has become the climate villain of agriculture due to its alleged substantial contribution to agricultural greenhouse gas (GHG) emissions (FFCC 2021). Livestock are claimed to contribute 14.5% of total anthropogenic GHG emissions (including both direct and indirect emissions), with beef and cattle milk making up 40% and 20% of the sector's contribution respectively. Of these emissions, 44% of the CO_2 equivalent is calculated to be made up of methane (CH_4), 279% nitrous oxide (N_2O) and 27% carbon dioxide (CO_2) (Gerber *et al.* 2013a: 15). Increases in income, population growth and rapid urbanisation are seeing a rise in demand for animal-source foods globally (Herrero *et al.* 2009; Nordhagen *et al.* 2020), with global average per capita dietary emissions projected to increase by 32% between 2009–2050 on a business-as-usual trajectory (Tilman and Clark 2014).

This has given rise to significant debate around the impact of animal-source foods on the environment and so how to reduce livestock's carbon footprint (UN Nutrition and Iannotti 2021). There have been loud calls across the media, campaign groups and policymakers to reduce the global consumption of animal-source food drastically, if not abandon it altogether (Wellesley *et al.* 2015; Godfray *et al.* 2018; Willett *et al.* 2019; Greenpeace 2020), driven by the assertion that meat and milk are bad, both for the environment and human health. For example, 50by40, an alliance involving a wide range of organisations, argues for a 50% reduction in consumption of animal-source foods by 2040.[1]

Even though the global, aggregate figures on emissions vary, the basic argument is that livestock, particularly ruminants, are large emitters of GHGs, notably methane, and that shifts in diets to reduce or eliminate meat and milk consumption will have a major impact on reducing emissions. A major 'protein transition' is envisaged whereby diets shift to low-impact alternatives, including vegetarian and vegan diets or meat diets without red meat. These alternatives would ideally be grown intensively in 'land-sparing' ways in order to release land for carbon sequestration through various means, notably large-scale afforestation (Hayek *et al.* 2021).

One strand of this narrative is heavily promoted by corporate interests, such as the ones represented at the World Economic Forum, and by some environmentalists, especially those with interests in animal rights or in tree-dominated landscapes. They make the argument for alternative protein sources, including cultured, cellular meats, fungus-based protein and insects (Godfray 2019; Warner 2019; Treich 2021).[2] The Farm Animal Investment Risk and Return Initiative, for example, argues that "Alternative proteins are promising to be the growth engine food for the food industry", offering lucrative environmental, social and governance investment opportunities.[3] In some of the discussion around the United Nations Food Systems Summit in 2021, this narrative is repeated.[4]

Extensive livestock systems have often been particularly criticised for their assumed low production efficiency, high per-animal methane emissions and the large extent of land use change when compared with more intensive systems (Stehfest *et al.* 2009; Gerber *et al.* 2013a). Through intensification, the argument goes, GHGs can be reduced and alternative land uses, including through tree-planting, can be encouraged, with overall lower carbon impacts. Of course if you feed a cow protein-rich fodder in a constrained feedlot, there will be less land used and less methane produced per animal, but climate outcomes depend on context. What are the options when available fodder comes from open rangelands and when the fibre content is high? Where does the feedlot fodder come from and what land use changes have resulted? Has it been grown on former forest land and transported across the world, for instance? What other benefits arise when livestock use extensive rangelands for feeding, such as the protection of landscapes or enhancement of ecosystems services?

The relationship between livestock and the environment is therefore much more complex than the current narrative reveals. Many global assessments do not sufficiently evaluate livestock systems in all their variations in a comprehensive, integrated way (Fairlie 2010; Herrero and Thornton 2013; Rivera-Ferre *et al.* 2016; Garnett *et al.* 2017; Manzano *et al.* 2021; Nagarajan 2021). This report argues that ways of assessing the climate impact of

> **"A climate policy that misses its mark and damages livelihoods is one that is inappropriate and unjust."**

Pastoralists on the road in Kachchh. Photo: Natasha Maru

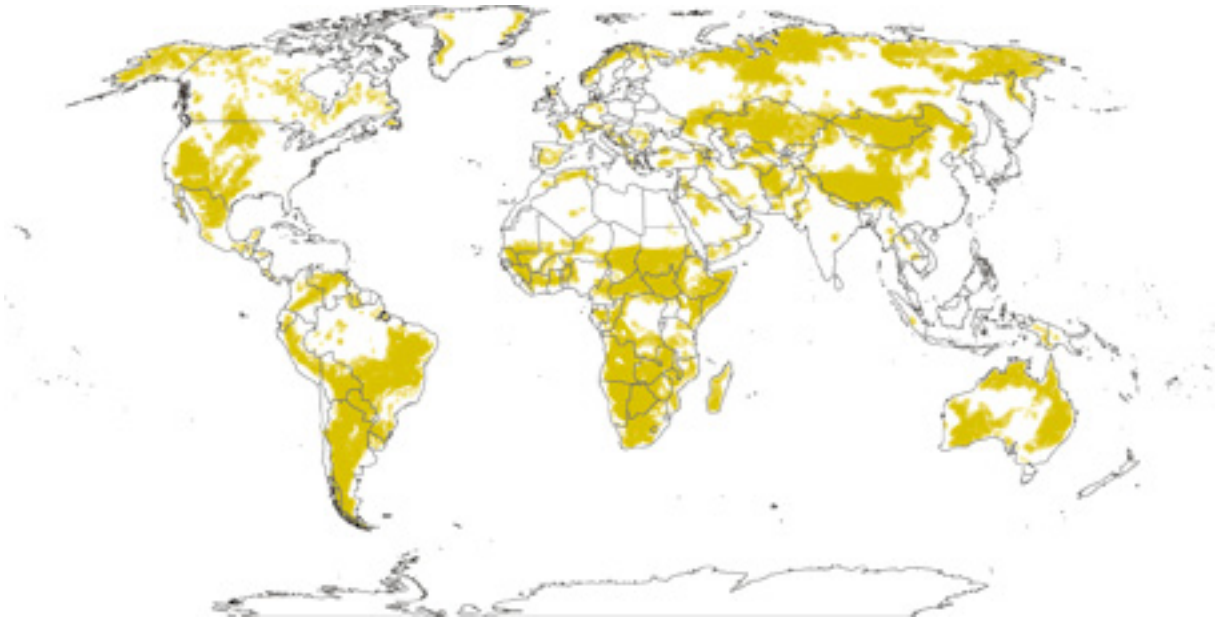
livestock fall prey to a set of core assumptions that lead to oversimplified, inaccurate messaging on how to manage the global livestock sector, particularly with regards to extensive, low-input livestock production, and especially mobile pastoralism where livestock are managed on open rangelands. The report examines why extensive livestock systems, including pastoralism, do not always fit the mainstream narrative, and why we must be cautious about accepting simple, generalised recommendations.

There are many different types of extensive livestock production, with varying integration with cropping systems. Extensive livestock production makes use of rangelands of different types and is characterised by the multi-functional use of livestock. Pastoralism is an important form of extensive livestock production and is a major focus in this report. Pastoralists are livestock keepers managing cattle, goats, sheep, camels, llamas, yaks, reindeer and other animals on extensive rangelands covering over half of the world's land surface (ILRI 2021). Many millions of people's livelihoods depend on extensive livestock production in such highly variable environments where alternatives do not exist. These include dryland savannas, parklands, deserts, steppes, Arctic tundra, Mediterranean hills and plains or mountains in many parts of the world. Pastoralists are found in every continent (except Antarctica) from the drylands of sub-Saharan Africa to the Arctic Circle, and are essential providers of animal protein for nutritious diets (Figure 1). Through careful, skilled herding, pastoralists make use of landscapes through different forms of mobility, making the most of variability and uncertainty (Krätli 2015; Manzano *et al.* 2021; Scoones 2021). Alongside small-scale livestock keepers, with greater integration into agricultural systems but still using extensive rangelands, pastoralists contribute significantly to human nutrition, providing high-density animal protein to often poor and marginalised populations (UN Nutrition and Iannotti 2021).

As forms of livestock production, pastoral and smallholder livestock systems are clearly very different to high-input, fossil fuel-dependent, intensive, contained livestock production systems. Each produces very different types of

The global distribution of pastoralism

Figure 1. Source: IUCN/UNEP (2015)



meat, milk and other foods. Although there are important climate-related impacts of any system, including smallholder livestock production and pastoralism, it is vitally important to distinguish between different approaches to producing animal products, differentiating between systems where livestock contribute to natural fluxes on extensive rangeland ecosystems and where all impacts are human-made in industrialised production.

This report critically reviews a wide body of literature concerned with livestock, climate change and human diet, examining three propositions:

1. *Current policy and advocacy narratives on livestock, diet and climate change are framed by a limited set of evidence, informed in particular by experiences of intensive, industrial agriculture. Problematic assumptions arise that significantly shape findings and thus recommendations.*

2. *Pastoralism and other low-input livestock systems (involving extensive use of rangelands with low external inputs and sometimes herd mobility) have a lower climate, biodiversity and water impact than the current narrative suggests, and can be highly beneficial to the environment.*

3. *Reframing the debate, taking account of different systems, suggests a way forward that emphasises the importance of low-impact, sustainable livestock systems in climate mitigation efforts. Compared to industrialised, contained livestock systems, these can offer wider livelihood and ecosystem benefits.*

The report first briefly outlines the mainstream policy narratives that dominate climate debates today. It then examines the underpinning evidence for such policy positions, along with the gaps and assumptions that lead to a misleading, partial narrative. Moving to the extensive rangelands across the world, it then unpacks these assumptions, suggesting an alternative framing that distinguishes between livestock systems. The report concludes with an assessment of the implications for climate mitigation interventions and policy.

> **"Extensive livestock systems exist in every continent except Antarctica and in nearly every country of the world, across more than half of the world's land surface."**

The simplistic and now widespread narrative that 'meat and milk are bad' is not universally applicable. Instead, we argue for a systems approach that takes account of the diversity of global livestock production systems and their different impacts on landscapes and livelihoods. Integrating contextual factors such as livelihoods, nutrition, food security and local agro-ecological conditions is essential. This will avoid committing to policy and behavioural changes to address the pressing global climate change challenge that may do more harm than good. An alternative approach would emphasise the opportunities offered by extensive livestock systems, including pastoralism, allowing responses to become more targeted and effective and with livestock keepers' voices heard in the debate.

However, this is not an argument for doing nothing, even in respect of extensive livestock systems. There is no doubt that livestock are major contributors to GHGs. Changes are essential if broad ambitions to reduce global temperatures are to be reached. A major system change in both consumption and production will be required as the carbon footprint of global agriculture and food systems is reduced.

A future agri-food system that includes meat and milk as part of the mix, we argue, should look towards animal-source foods produced in pastoral and other extensive livestock systems as part of the solution, preserving and indeed enhancing the livelihood and environmental benefits of extensive systems. The integrated systems approach we advocate, we suggest, avoids the dangers of a one-size-fits-all approach, and encourages us to explore different pathways suited to particular places and contexts.

This report has emerged from work on pastoralism and development under the European Research Council (ERC)-funded PASTRES research programme, which is working across six countries and three continents exploring how pastoralists are responding to uncertainty, including through climate change.[5] The report is co-published with a number of other organisations that are also engaged with pastoralism, conservation and climate justice (see Appendix 1 for details).

The ‘meat and milk are bad’ narrative

Yak milking in Amdo Tibet. Photo: Palden Tsering

The current narrative on livestock, climate change and human diet advocates a drastic reduction or elimination of animal-source foods from global diets due to the large climate impact of livestock compared to cropping systems (Wellesley *et al.* 2015; Willett *et al.* 2019; Greenpeace 2020). According to the International Panel on Climate Change's (IPCC) major report on climate and land use (IPCC/Shukla *et al.* 2019: 159–160, Figure 2.9), which bases its calculations on a number of datasets, livestock production is responsible for 33% of total global methane emissions and 66% of agricultural methane emissions. The largest livestock emissions are estimated to come from Asia (37%), with livestock-related emissions growing the fastest in Africa (from 14% in 2018). Methane is sourced from ruminants with a high proportion of fibre in their diets, so pastoralist, agro-pastoralist and mixed crop-livestock systems are significant contributors to these emissions.

Since the publication of the influential United Nations Food and Agriculture Organisation's (FAO) *Livestock's Long Shadow* report (Steinfeld *et al.* 2006), which was a call to action that highlighted the significant environmental consequences of livestock production, global attention has turned towards the livestock sector. This landmark report states that the sector "emerges as one of the top two or three most significant contributors to the most serious environmental problems, at every scale from local to global" (Steinfeld *et al.* 2006). Despite multiple critiques of the report's methodology and conclusions (e.g. Pitesky *et al.* 2009; Glatzle 2014), this position has since fed rising concern about the climate impact of animal-source foods among academics, campaign groups, business organisations, journalists and environmental activists, including high-profile figures such as Bill Gates, Greta Thunberg and David Attenborough.[6] Changing diets to save the planet has become a rallying cry from everyone, ranging from environmental activists promoting veganism to high-tech corporates offering low-carbon protein alternatives.[7] Despite attempts to qualify assessments,[8] this has culminated in the current narrative that paints the livestock sector as central to the world's climate catastrophe.[9]

Where does this now dominant narrative come from? Based on repeated mentions in the media and other policy documents, we identified nine key reports published between 2006 and 2020 as particularly influential in the wider debate on livestock, climate change and food futures (Box 1).[10] Starting from the FAO's *Livestock's Long Shadow*, they include contributions from a range of influential think-tanks, campaign organisations alongside the IPCC's important report on climate and land use. Where these can be traced, many reports share the same sources of data and modelling to frame their conclusions. Some are more nuanced than others, differentiating industrial and other forms of livestock production, but all offer more or less the same set of recommendations around human diet change and the reduction of livestock production to reduce emissions.

Recommendations that animal-source food consumption and livestock production should be drastically reduced to relieve pressure on the environment and to stay within the 1.5°C warming limit of the Paris Agreement[11] are now commonplace, and appear to be part of 'common-sense' policy positions. The much-cited EAT–Lancet report asserts that animal-source foods have the largest environmental footprint per serving across several indicators, including GHG emissions, cropland use and water use. The report therefore calls for a 50% reduction in red meat consumption by 2050 in order for global agriculture's impacts to stay within planetary boundaries (Willett *et al.* 2019. Greenpeace (2018), meanwhile, has made a call for a 50% reduction in all animal-source products by 2050. The *Farming for Failure* report (Greenpeace 2020: 10) states that "the increase in total annual emissions from animal farming in Europe compared to 10 years before (39 $MtCO_2$-eq) is equivalent to the climate impact of 8.4 million additional cars on the road."[12] Similarly, the *Changing Climate, Changing Diet* report from Chatham House (Wellesley *et al.* 2015: 1) declares that "the production of animals and of crops for feed alone accounts for nearly a third of global deforestation and associated carbon dioxide emissions", and that the livestock sector is "highly resource intensive". The key lesson Searchinger *et al.* (2019) draw from their analysis of four alternative diet scenarios is that a reduction in the consumption of ruminant meat is

key to determining environmental outcomes, particularly among the world's highest consumers of meat, where consumption rates may exceed 100 kg of red meat per annum (see below).

Within this overarching narrative, extensive systems – such as pastoral, agropastoral and low-input crop-livestock production – are assumed to be responsible for the highest per-animal GHG emissions, due to low production efficiency and higher methane emissions from lower-quality diets (Steinfeld *et al.* 2006; Garnett *et al.* 2017). While it is true that per-animal methane emission levels are high, adding to already high natural methane fluxes, there are other mitigating factors that

Some key reports influencing wider debate on livestock and climate change

Box 1

REPORT TITLE	ORGANISATION	AUTHOR	DATE
Farming for Failure: How European Animal Farming Fuels the Climate Emergency	Greenpeace	Greenpeace	2020
Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems	IPCC	Shukla *et al.*	2019
Food in the Anthropocene: the EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems	EAT–Lancet Commission	Willet *et al.*	2019
Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050	World Resources Institute (WRI)	Searchinger *et al.*	2019
Less is More: Reducing Meat and Dairy for a Healthier Life and Planet	Greenpeace	Greenpeace	2018
Grazed and Confused: Ruminating on Cattle, Grazing Systems, Methane, Nitrous Oxide, the Soil Carbon Sequestration Question – And What It All Means for Greenhouse Gas Emissions	Food Climate Research Network	Garnett *et al.*	2017
Changing Climate, Changing Diet: Pathways to Lower Meat Consumption	Chatham House	Wellesley *et al.*	2015
Tackling Climate Change through Livestock	United Nations FAO	Gerber *et al.*	2013
Livestock's Long Shadow	United Nations FAO	Steinfeld *et al.*	2006

suggest that overall net emissions and the anthropogenic global warming effects may be much lower, as discussed further below (Liu *et al.* 2021). However, the persistent perception of extensive systems as high emitters means policy measures are likely to target low-input, low-output extensive systems disproportionately (Manzano and White 2019).

Box 2 summarises 10 key claims about the relationship between livestock and climate change that inform the mainstream narrative. While there are important qualifications and nuances in some reports and assessments, and some campaigns only target industrial farming, the wider, generalised narrative still has purchase on public and policy debates.

Ten claims about livestock and climate change

Box 2

1. 	Emissions from agriculture are projected to increase to 52% of global emissions in the next decades, with approximately 70% of the increase coming from animal and dairy farming (Greenpeace 2020).
2. 	Livestock production is responsible for approximately 33% of global methane emissions and 66% agricultural emissions (IPCC/Shukla et al. 2019).
3. 	Livestock produce approximately 18% of global calories consumed, but use 83% of all farmland (Poore and Nemecek 2018).
4. 	An estimated 33% of global cropland is used to grow animal feed (Poore and Nemecek 2018).
5. 	Per unit output, animal-sourced foods have a higher environmental footprint than plant source foods. Ruminant animals have the highest impact, between 20 and 100 times more than plant-based alternatives (Clark and Tilman 2017).
6. 	Animal and feed production contributes significantly to deforestation and land use change, accounting for nearly one-third of global deforestation and associated emissions (Wellesley et al. 2015).
7. 	Extensive livestock systems are associated with higher GHG emissions due to low production efficiency and higher methane emissions from low-quality diets (Steinfeld et al. 2006; Garnett et al. 2017).
8. 	Red meat consumption needs to reduce by 50% by 2050 for the food system to remain in a 'safe operating space' (Willet et al. 2019).
9. 	A 75% reduction in animal farming would save an equivalent of 376 million tonnes of CO2 emissions (Greenpeace 2020).
10. 	A 50% global reduction in the production and consumption of animal-sourced foods is needed by 2050 (Greenpeace 2018).

“The mainstream narrative, generated from aggregated data from a narrow set of cases, ignores the particularities of extensive livestock systems.”

Khang Chag. Amdo Tibet. Photo: Palden Tsering

Life cycle analyses: the data behind the narrative

The driving force behind the mainstream narrative and the claims made is the life cycle assessment (LCA) methodology, sometimes informed by standardised emissions inventories. LCAs are a widely used framework, employed to calculate the environmental impacts of products, processes and services through their life cycles (Hallström *et al.* 2015), including in food production systems (Clark and Tilman 2017). The majority of studies on the climate impact of different foods and diets adopt this methodology, and the influential reports cited earlier all draw from such studies.

There is a high level of agreement among LCA studies that animal-source foods have a greater environmental impact than plant-based foods, and that a global shift towards a plant-based diet would result in reductions in GHG emissions, land use change and other negative impacts such as eutrophication and acidification.[13] There is also consensus that, within animal-source foods, meat from ruminants has the highest climate impact. This is estimated to be 20 to 100 times that of plant-based alternatives per kilogramme of food produced, gramme of protein, USDA serving or unit mass (Springmann

et al. 2016a, 2016b; Clark and Tilman 2017; Clune *et al.* 2017; Searchinger *et al.* 2019). As a consequence, the greatest emissions reductions can be achieved through decreasing red meat consumption (Springmann *et al.* 2016a, 2016b). An analysis from Springmann *et al.* (2018) quantifies this, stating that the average global citizen must reduce their red meat consumption by 75% and that western consumers must reduce consumption by 90% in order to meet global emissions reductions targets. However, focusing only on aggregate 'protein' may be inappropriate. The energy and nutrient density of foods and their carbon footprints are quite different (Drewnowski *et al.* 2015). Looking at accessible nutrients and specific human requirements, not simply aggregate protein per serving, is essential for more informed assessments.

A study by Poore and Nemecek (2018), published in the high-profile journal *Science*, has been especially widely cited by policymakers, campaigners and media articles advocating for dietary shifts. Their data have been widely used, for example, in the excellent data visualisations and analyses of Our World in Data, a valuable source for researchers and journalists alike.[14] Based on a meta-analysis of 38,700 farms and 1,600 processors from around 570 studies across 119 countries, they found that dietary changes to exclude animal-source foods could change land use across 3.1 billion hectares (equivalent to a 19% reduction in arable land) and reduce GHG emissions by 49%, acidification by 50% and eutrophication by 49%.[15]

Data from LCA studies, and especially global syntheses and models that aggregate across LCA-derived estimations,[16] now inform global policy recommendations, media and public opinion. Various, sometimes contradictory 'iconic facts' based on the statistics generated from the models are used to justify major changes. However, as authors of scientific papers usually admit – often buried in footnotes and in supplementary materials – the application of LCA methodologies inevitably involves a set of assumptions. In the case of Poore and Nemecek's (2018) analysis the assumptions are clear, both in the paper and in the 76 pages of supplementary materials. They only looked at 'commercially viable' and so mostly industrial livestock systems. They examined emissions from production to retail, but not sequestration or other environmental benefits. Their cases came mostly from Europe, North America, Australia, Brazil and China, and in order to generate a global picture they applied weighting factors both within and between countries. Working in the context of data constraints, even with an enviably large dataset, their approach inevitably had limitations. However, when the headline figures are used in press releases[17] and media commentaries,[18] without wading through the detail, such studies may mislead; for example by making false equivalences between livestock production and car or plane transport.[19]

Here it is vital to separate out direct and indirect emissions. Global livestock assessments based on LCAs show a 14.5% contribution to global emissions, encompassing both direct emissions from production as well as indirect contributions from, for example, transport (Gerber *et al.* 2013a). By contrast, global assessments of transport-related emissions tend to focus only on direct emissions. While these may add up to around 14% of total GHG emissions, the equivalent direct emission figure for livestock is 5%, with the rest of the total made up of indirect emissions. As we discuss further below, low-input, extensive systems' direct emissions may be even lower than those estimated in 'global' LCAs if carbon sequestration and other factors are taken into account and, at the same time, indirect emissions in such systems are also limited, given a low dependence on transport, imported feed and other infrastructure.[20] Flawed comparisons and a failure to differentiate between emission sources therefore can result in highly misleading conclusions, with climate change policies being inappropriate and potentially damaging to extensive livestock keepers across the world.

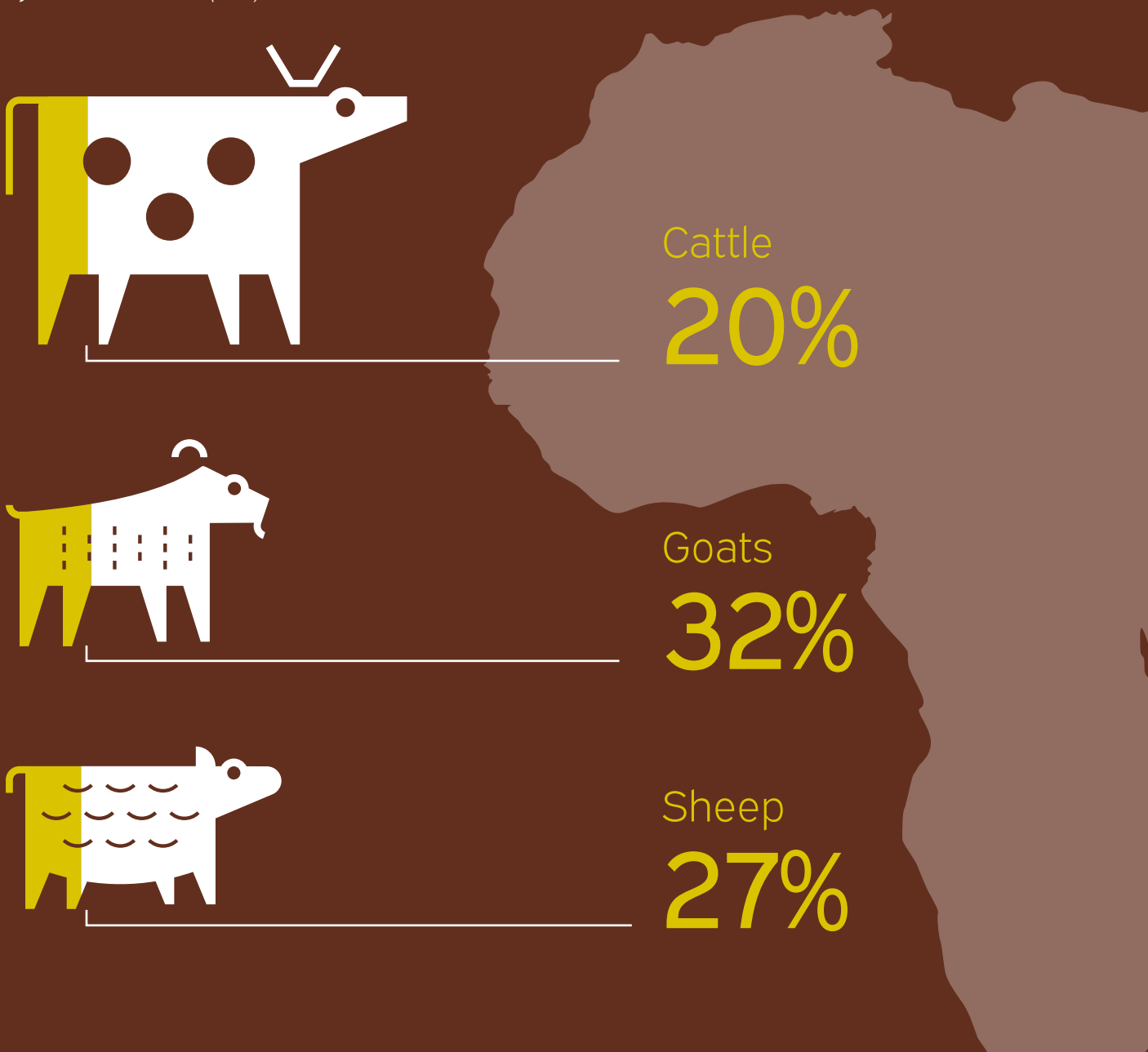
‘Global’ assessments:
The dangers of aggregation and generalisation

Goat and herder, southern Tunisia. Photo: Linda Pappagallo

'Global' LCA studies (frequently using very selective data) have therefore exerted substantial influence on how sustainability is perceived (Manzano and White 2019). For the most part, LCAs draw on data from high-income countries, where agricultural systems are more industrialised (Paul *et al.* 2020). For example, within the livestock-related literature published between 1945 and 2018, just 12.7% covers Africa, despite the continent being home to 20%, 27% and 32% of global cattle, sheep and goat populations respectively (Gilbert *et al.* 2018; Paul *et al.* 2020). There is as a result a noticeable lack of low- and medium-income country perspectives in the literature and a lack of data collected in such countries. Clark and Tilman's (2017) meta-analysis included 164 LCAs, the majority of which were from Europe, North America, Australia and New Zealand. Only 0.4% of LCAs of food products came from Africa (Clark and Tilman 2017; Figure 2). Similarly, a systematic review from Aleksandrowicz *et al.* (2016) covered 210 dietary scenarios: 204 from high-income countries, one from a middle-income country and five global dietary patterns. None of the reviewed scenarios was exclusively from a low-income country context.

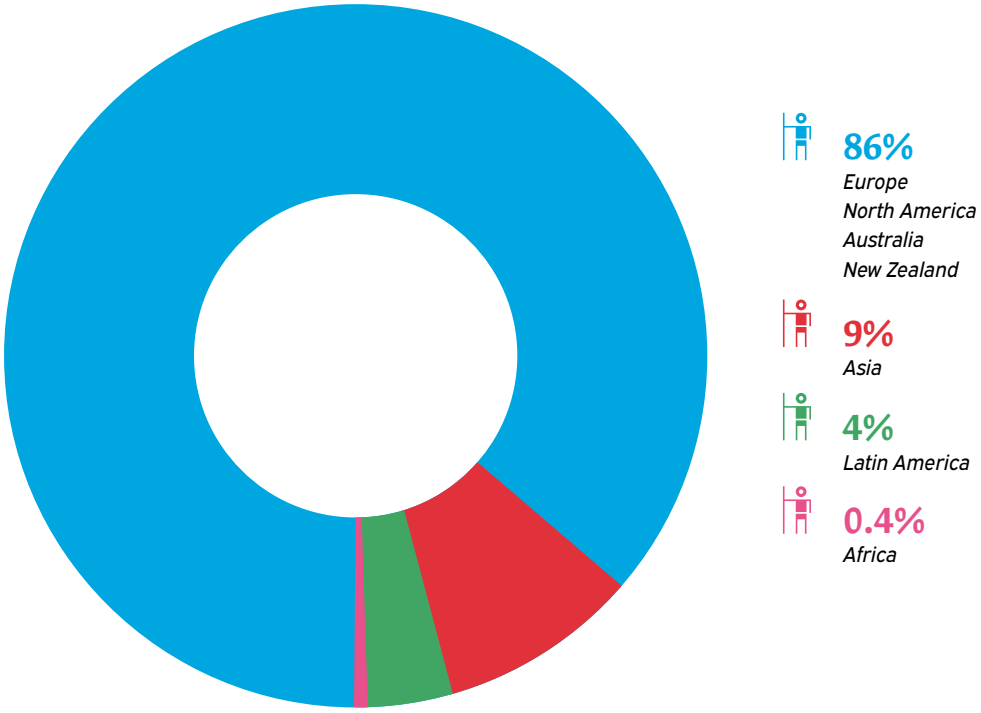
% Global Ruminats in Africa

Figure 2. Source: Paul et al. (2020)



Regions covered by 164 Life Cycle Analyses

Figure 3. Source: Clark and Tilman (2017)



The perspectives of nutritionally vulnerable, poor populations are therefore often missing or underrepresented in scientific analyses of animal-source food and climate change, and their needs are neglected in the creation of climate mitigation policy (Adesogan *et al.* 2020), yet livestock's climate impact varies highly depending on geography and type of production system (Herrero and Thornton 2013; Smith *et al.* 2013). There have been many calls for more evidence specific to low- and middle-income countries in order to inform a more nuanced, balanced discussion of livestock sustainability (Hallström *et al.* 2015; Johnsen *et al.* 2019; Nordhagen *et al.* 2020; Paul *et al.* 2020).

Sustainability and livelihoods

As the majority of LCA studies focus on high-income countries, certain sustainability indicators are prioritised in the literature. However, sustainability priorities vary regionally and across production systems (Niamir-Fuller 2016). A recent survey conducted by Paul *et al.* (2020) found that, in Europe, experts prioritised GHG emissions, whereas African experts prioritised soil and land degradation, followed by land use, with GHG emissions less emphasised. Notably, many LCAs assess only a limited set of impacts, most commonly GHG emissions and land use (McClelland *et al.* 2018), and data for other environmental indicators are comparatively scarce (Nordhagen *et al.* 2020; Sahlin *et al.* 2020), with only a patchy focus on potential environmental benefits of livestock production, including sequestration and biodiversity maintenance. Lack of national capacity for data collection feeds this bias, with many statistical offices around the world relying on very rough estimates.

The emphasis of LCA studies on high-income countries means that the significant contribution of livestock to sustainability through livelihoods, particularly across the Global South, is frequently ignored. Livestock supports the livelihoods of at least 1.3 billion poor, rural households (Herrero and Thornton 2013; Garnett *et al.* 2017) through nutrition, income, asset provision, insurance and nutrient cycling (Herrero *et al.* 2009; Mehrabi *et al.* 2020; Paul *et al.* 2020). One survey of 13 low-income countries in Asia, Latin America and Africa found that livestock provided 10%–20% of average rural income in each of the three lowest of five income categories (Pica-Ciamarra *et al.* 2011).

As a result, the literature based on LCA analyses rarely accounts for the socioeconomic trade-offs that come with a transition to plant-based diets for communities in poor, vulnerable contexts. The skew of the literature towards affluent contexts is again to blame here, as livelihoods in richer countries generally rely less directly on crop farming and livestock rearing. Extensive, sometimes mobile, livestock systems can often be the only options to sustain livelihoods of people whose contribution to global emissions is already extremely low (Herrero *et al.* 2009; Rivera-Ferre *et al.* 2016), and calls for 'sustainable intensification' may miss the value of production from such settings. Ignoring the complexity of livestock systems in such environments not only threatens their survival, but also the erosion of cultural values and knowledge that are especially relevant for climate change adaptation (Herrero *et al.* 2009; Mehrabi *et al.* 2020).

> **"The perspectives of nutritionally vulnerable, poor populations are often missing or underrepresented in scientific analyses"**

Nutrition and diets

From a nutritional standpoint, recommendations to shift to a plant-based diet based on high-income country perspectives can have a negative impact on the global appreciation of animal-source foods in the diets of those who struggle to access key nutrients (Adesogan *et al.* 2020). A focus on aggregate 'protein' rather than on essential amino acids can give a distorted picture (Moughan 2021). For vulnerable populations, animal-source foods are a requirement for adequate nutrition, reducing stunting and wasting and improving cognitive health, especially in the first months of life (Alonso *et al.* 2019; Adesogan *et al.* 2020; Mehrabi *et al.* 2020). Animal-source foods may be especially important in certain environments, such as at high altitudes and in cold climates (Guo *et al.* 2014). Diets without animal-source foods typically must include a wide variety of plant-based foods and combine various food types in order to provide sufficient nutrition. Issues of affordability, knowledge and access to resources make achieving this difficult, particularly in poorer settings (Nordhagen *et al.* 2020). Therefore, animal-source foods are vital for nutrition, where nutrition gaps are evident (Beal *et al.* 2021; Morris *et al.* 2021; Ryckman *et al.* 2021).

Therefore, large reductions in animal-source foods by everyone would be highly inequitable, with impacts being disproportionately felt by low-income, rural populations in low- and middle-income countries (Searchinger *et al.* 2019; Nordhagen *et al.* 2020). This is especially true as consumption of animal-source foods in these countries is already low. In 2009, the 15 richest nations had a 750% greater per capita demand for meat protein than the 24 poorest nations (Tilman and Clark 2014). Therefore, any mitigation recommendations need to adopt a context-specific, pro-poor approach that assesses nutritional, environmental and livelihood outcomes in an integrated way.

Limiting assumptions:
Why standard assessments need interrogating

Reindeer crossing stream. Photo: IYRP - Svein D. Mathiesen

As the dominant approach to global assessments of the climate impacts of livestock, and so the generator of key 'iconic facts' in policy debates, it is worth interrogating the LCA methodology – alongside its assumptions – a little further. Beyond the lack of data from low- and middle-income countries, there are a number of limitations to the approach. These are widely admitted by scientists undertaking assessments, but very often the qualifications and caveats do not find their way into press releases and policy statements. This can have big consequences, resulting in misleading recommendations.

The LCA methodology calculates the net emission impact for each unit of throughput; in this case, an animal or weight of meat or cheese or volume of milk. As with any assessment, there are a set of bounding and framing assumptions that affect the results, and there are multiple uncertainties. Most LCAs estimate the life cycle of a product from production to consumption, or at least to retail outlets. This may include the costs of installed infrastructure, transport and processing, which involve considerable fossil fuel emissions in industrialised systems. However, many LCAs consider only farm-scale emissions, ignoring downstream emissions, so narrowing the scope of the assessment. By contrast, other assessments take a broader view and may include wider environmental costs and benefits, and so the impacts on carbon loss or sequestration from grazing and browsing.

How system boundaries are drawn and what outputs are included has a big impact on the conclusions. The productivist logic of industrial production focuses only on marketed outputs, such as meat and milk, but in multi-functional livestock systems an array of benefits are derived. Taking a wider view may also highlight more of the costs of industrial systems – with long transport chains and environmental costs, such as the production of slurry and water and air pollution, for example (Weis 2013; Domingo *et al.* 2021) – while highlighting the beneficial impacts of extensive systems.

Assessments must also define a baseline against which to analyse impact. It is often assumed that areas that are used for extensive livestock could alternatively be carbon sinks based on extensive forest cover. This assumes that alternative 'land-sparing' options are feasible and in turn beneficial in terms of carbon budgets, as well as other co-benefits such as biodiversity enhancement. This may not be the case, as a simplified assessment (for example, with a model that takes all grazed areas and replaces them with closed forest) may ignore the particular ecological conditions of dry or montane rangelands where pastoralists live, or alternative baselines where large ungulate wildlife populations replace livestock (Manzano and White 2019).

Such considerations also ignore the important role that fire has had in shaping most terrestrial ecosystems over millions of years (Bond 2019). The question about wildfires is not whether they are going to happen, but when. Carbon in the soil is safer from fire than carbon in leaves and branches, so grasslands and parklands have a better capacity to store carbon in the long term than closed forests (Holdo *et al.* 2009; Dass *et al.* 2018). If large herbivores are present in the ecosystem, they contribute both to suppressing fire and to incorporating additional carbon into the soil (Johnson *et al.* 2018). Elevated CO_2 concentrations in the atmosphere will also increase carbon fixation by grasslands in soil, but not fixation by forests (Terrer *et al.* 2021).

Generalised models lead to generalised, often inappropriate results, as assumptions are inaccurate. While there is no dispute that the climate impacts of livestock must be addressed, the question is which livestock and where. Too often, the recommendations of even scientific bodies like the IPCC are based on a standard model, without nuance. For example, in the IPCC's landmark report on land use and climate (IPCC/Shukla *et al.* 2019), a list of apparently simple technocratic mitigation measures is proposed, many of which aim for the intensification of extensive livestock systems (Table 6.5: 570).[21] These were derived from literature reviews of 'global' systems, plus the results of various LCA models (Gerber *et al.* 2013a; Herrero *et al.* 2016; Rojas-Downing *et al.* 2017). Yet, they are not well-attuned to very diverse contexts of extensive livestock production.

Despite the undoubted uses of models, they can therefore have a distorting effect. Of course, all models are inevitably rough approximations and, with assumptions specified and limitations presented, they can be useful to

> **"Assumptions embedded in many Life Cycle Analyses lead to an overestimation of emissions from extensive livestock settings."**

Herds in the High Atlas mountains in North Africa. Photo: Inanc Tekguc

generate debate. They can highlight the importance of the issue and signal an important direction of travel, even if not specifying precisely what to do. However, models have a political role in policy debates too and they often carry far more weight than they should because of how they can conveniently simplify complex issues, carrying with them embedded assumptions and often particular political and institutional commitments.

As we have already discussed, the narratives that frame the debate are largely concerns of northern campaigners and business interests, including those advocating a particular form of diet change (including to high-tech alternatives, with big financial backing) and those from some conservation lobbies, advocating for 'fortress conservation' models and 'land-sparing' alternatives to livestock production.[22] Models therefore always emerge from their context, and few reflect the priorities of pastoralists and marginalised livestock producers across the world. In offering definitive solutions, even if couched around multiple scenarios, models (and the data and iconic statistics that they generate) have power and influence.

For this reason, interrogating the assumptions within the models and the statistics they generate is important to ensure justice in the climate debate. By taking another set of assumptions, a very different scenario may be revealed, one that may challenge the dominant narratives. In this way the policy debate is opened up to alternative perspectives currently hidden from view.

Box 3 offers a list of some of the common gaps and assumptions that are embedded in the standard application of LCA methodologies, which may introduce unexpected, inadvertent biases in the results (see also Johnsen *et al.* 2019). They are grouped into three: biases in the data used; the definition of systems also deployed; and the baselines and alternatives assumed.

Ten gaps and assumptions in mainstream assessments

Box 3

DATA

1. **BIASES IN THE DATA:** The majority of LCA analyses make use of data from high-income countries, mostly Europe and North America, and some parts of Latin America. These are predominantly industrial systems. There is a severe lack of data for low- and middle-income countries, especially from extensive pastoral settings. This means that most assessments are not 'global' as claimed, but instead are quite partial.

2. **DEFAULT EMISSIONS FACTORS:** The lack of empirical data collected for low- and middle-income regions means that many studies use default emissions factors calculated by the IPCC to estimate emissions produced by livestock in these areas. Recent studies have shown that these default figures overestimate actual animal emissions in extensive low-input systems. Generalising from high-input industrialised systems (where the data lies) to the rest of the world can result in hugely misleading results.

3. **GHG MEASURES:** In order to assess the emissions across a number of GHGs (CO_2, CH_4, N_2O), a standard unit is required. Conventionally this has been measured in terms of CO_2 equivalence, with equivalence assessed in relation to 'global warming potential'. The factor used in this calculation may overestimate the influence of methane due to its short half-life in the atmosphere. Methane production by livestock also varies dramatically depending on feed intake and genetics. Current estimates used in LCA models may significantly overestimate methane production for pastoral livestock.

SYSTEMS

4. **CONCEPTUALISING 'EFFICIENCY':** The mainstream framing of efficiency prioritises the maximisation of output per animal, with impacts linked to emissions per unit of product (meat or milk). Extensive systems are deemed the least efficient, although they productively make use of areas that have limited alternative uses. Wider systems-level assessments are required to capture multi-functional uses of livestock and diverse impacts.

5. **LIVESTOCK AND THE CARBON CYCLE:** LCA methodology assumes that the soil carbon balance is in long-term equilibrium, and that the presence of livestock adds extra emissions. However, in low-input pastoral systems, recent studies have shown that the presence of livestock can keep the carbon cycle balanced, or even slightly negative. Carbon sequestration in rangelands is shown to be significant under certain grazing conditions, including light grazing in extensive, mobile systems.

6. **SPATIAL AND TEMPORAL DYNAMICS:** Making an aggregate assessment of impacts misses important patterns of spatial heterogeneity and temporal variability. Emissions may be positive and negative in the same area at different times, requiring much more focused mitigation measures.

7. **ECOSYSTEM SERVICES:** Bounded farm-level LCA assessments often do not recognise that livestock, particularly in low-input, pastoral systems, offer important ecosystem services that maintain the landscape, the water cycle and biodiversity, while also reducing the environmental risks of fire, flooding, etc.

BASELINES AND ALTERNATIVES

8. 

ALTERNATIVE LAND USES: An assumption of many LCA assessments is that the abandonment of livestock rearing – especially extensive systems – would result in beneficial, 'land-sparing' rewilding/ regeneration of the land, allowing more effective carbon sequestration. If not, tree-planting initiatives are frequently envisaged as an alternative to livestock production. Increases in crop farming to produce plant-based alternatives to animal protein also have major consequences. However, studies have shown how grasslands, due to extensive root systems, may have higher carbon sequestration potentials than trees and less vulnerability from wildfires, and tree-planting schemes have very often failed in harsh dryland and montane environments.

9. 

NICHE REPLACEMENT: In reducing extensive livestock-based land use, the alternative will not just be a vegetation carbon sink. The niche left by livestock would likely be filled by wild ruminants and termites, with potentially significant effects on the landscape and carbon emissions. The pre-livestock baseline of wildlife-based landscapes is likely to have had high carbon emission levels, perhaps comparable to that of extensive livestock systems.

10. 

CONSUMER CHOICE AND DIETARY PATTERNS: Hypothetical dietary scenarios in LCA studies often assume meat will be replaced with low-emitting, high-yielding alternatives. However, this does not usually match realistic consumer choice, dietary patterns and bioavailability of nutrients. Alternatives based on industrial meat or milk substitutes may have significant environmental impacts, alongside the further concentration of power in the food system.

Data biases

Data availability

The availability of data for use in assessments is limited and particularly focused on industrialised systems in high-income countries. Extensive livestock production systems are poorly represented in systematic national data collection and so not part of statistical datasets, while experimental approaches tend to replicate high-input systems. Without livestock keepers themselves being involved in defining the questions and collecting the data, there are inevitable biases.

As a result, most assessments, despite being projected as 'global', are in fact quite selective. While the data unquestionably highlight the problems with high-input systems, especially those linked to long market chains and with high dependence on fossil fuels, the data are often extrapolated to other systems or to the global level, applying within-country and between-country weighting to address data gaps (see, for example, Poore and Nemecek 2018: supplementary materials).

Due to the lack of data, assumptions about GHG emissions from low-input extensive systems are often applied from inappropriate experimental settings. Ruminant livestock feeding off low-quality rough forage are certainly likely to produce more methane per animal if feed rates are high. With very little data on extensive systems, the extrapolations and generalisations may be inappropriate. Assumptions may be inaccurate especially for mobile systems, where intakes are low and are often supplemented through browse intake with high nutrient content. Animals in such settings also have behavioural and physiological adaptations to variable environments (see below), and production tends to be more efficient than in sedentary grazing systems because of profiting from vegetation productivity peaks.

GHG units

To assess livestock's climate impacts, GHG units are applied. A particular difficulty for global assessments

"Which livestock, and where? What diet changes, and for whom? Are tree-planting and land-saving alternatives realistic or effective?"

Cattle in Borana, Ethiopia. Photo: Masresha Taye

and impact modelling is the combination of different contributions to overall emissions, ranging from methane emissions from enteric fermentation in animals to the use of fossil fuels for transport and embodied carbon in infrastructure. Disaggregating these contributions and in turn assessing their influence on global warming is challenging (Lynch 2019). Comparing emissions from livestock systems (where methane emissions dominate) to other sectors, such as transport (as favoured by some campaign groups), is not appropriate (Lynch *et al.* 2021). Cars and cows are simply not the same.[23]

Why can't we easily compare cars and cows? The reason is that carbon sources and their contribution to GHGs, and so to climate warming, are not equivalent. The convention in most emissions assessments, including via LCAs, is to generate a CO_2 equivalent measure, assessed per unit of output (or sometimes area) per year. Since many different GHGs contribute to emissions, there is a need to make them equivalent in the calculations. Here, 'global warming potential' (GWP) becomes important, as different gases behave differently in the atmosphere. Estimates are made for a 100-year period (GWP_{100}), and figures are combined. Methane is a particularly potent GHG, and current standards suggest its GWP_{100} is 28 times higher than that of CO_2. However, it is a short-lived pollutant and its presence declines quite quickly, usually over 9–12 years. By contrast, CO_2 has less warming potential, but it persists, potentially forever. A single unit of CO_2 equivalent used within models may confuse: reducing CH_4 emissions is essential especially for the short term, but a focus on CO_2 is imperative for the long term (Ritchie 2020).

Modelling emission impacts across GHGs is therefore challenging, requiring careful choice of appropriate models and parameters. However, many argue that the GWP_{100} factor overestimates the long-term influence of methane, and so the impact of livestock on climate change. Nevertheless, in the short term, methane has higher impacts, with GWP_{20} (over 20 years) estimates up to 84 times that of CO_2. In most GHG emission assessments for livestock systems, methane makes up around half of total emissions, so changes in the way gases are treated makes a big difference (Ritchie 2020).

Data from extensive, pastoral settings suggest that existing emission estimates may be overestimates. Pastoral livestock eat much less than assumed,

particularly in drier years (Assouma *et al.* 2018a). At key times of year, they may eat significant amounts of plant species with varied secondary compounds that have anti-methanogen properties (e.g. condensed tannins) (Katijua and Ward 2006; Schmitt *et al.* 2020). Their feeding and grazing strategy, even on what appears to be dry and rough grazing, may also be highly selective (Ayantunde *et al.* 1999). Feeding selection can be enhanced by the training of animals by herders and careful, sensitive herding to allow green bites to be gained, and so higher-quality fodder. This is facilitated in pastoral systems by highly skilled herding and mobility to take advantage of a heterogeneous forage resource (Krätli 2008; Krätli and Schareika 2010).

Rates of production of methane by different animals may also be inaccurate for low-input, extensive grazing systems. Standard methane production levels are calculated based on assessments from well-fed animals in controlled experimental settings, based on different diets. While methane production certainly increases in ruminant animals when forage quality declines, total methane production depends on the level of intake, the diet and the genetics of the animals (Hristov 2013a, 2013b; Montes *et al.* 2013; Beauchemin *et al.* 2020).

More data on methane production and mechanisms to offset in pastoral settings is urgently needed, alongside a radical revision of the factors used. Recent studies have suggested the use of a revised GWP* measure, which differs from the standard used to date by most LCAs, as previously recommended by the IPCC. GWP* accounts for the differences between short-lived and long-lived gases over time by relating cumulative CO_2 emissions to the current rate of emission of short-lived climate pollutants, such as methane (Allen *et al.* 2016, 2018; Cain *et al.* 2019).[24] For example, using this approach, Del Prado *et al.* (2021) found that the whole European sheep and goat dairy sector had not contributed to additional warming in the period between 1990 and 2018. Into the future, although some feed-based mitigation measures will certainly be required, this core pastoral economy in Europe could achieve climate neutrality and potentially net positive contributions if soil organic carbon in pastures is included.

This has important implications for mitigation. While CO_2 emissions must reach net zero to stop temperatures increasing, methane emissions can be sustained indefinitely – although below current levels – without temperatures increasing further.[25] Changes in measurements, accounting for the behaviour of different types of gas in the atmosphere, will therefore result in a very different set of results in LCA assessments, although measurements in terms of total emissions or emissions per capita will of course look very different in different parts of the world.

Taking account of the contrasting effects of GHGs will hopefully provide the basis for differentiating different types of livestock production system, depending on feeding patterns and methane production. However, while GWP* measures may suggest that methane is less significant, the requirement to reduce emissions still remains, particularly in the shorter term. The large divergence in assessment results therefore requires more effective dialogue across those focusing only on CO_2 and those looking at different types of GHGs and their contributions, especially in the tropics (Roman-Cuesta *et al.* 2016a, 2016b).

Default emissions factors

Because LCA research is focused on high-income countries, there is a lack of empirical evidence collected in low- and medium-income regions (such as sub-Saharan Africa), as we have discussed (ILRI 2018).[26] When there is a lack of *in situ* data for a certain region, the results are extrapolated from existing data. Many LCA applications rely on the IPCC Tier I protocol. This is a set of default emissions factors calculated by the IPCC from the existing body of scientific literature (IPCC 2006; Goopy *et al.* 2018; Rowntree *et al.* 2020). As empirical evidence is only just now starting to become available for extensive systems in low- and medium-income nations,[27] emissions estimates for tropical ecosystems rely heavily on the default IPCC values. This results in large uncertainties around LCA assessments (Assouma *et al.* 2018a; Goopy *et al.* 2018, 2021; Ndung'u *et al.* 2019); and this is even the case in well-studied production systems in temperate rangelands in the United States (cf. Stackhouse-Lawson *et al.* 2012; Stanley *et al.* 2018).

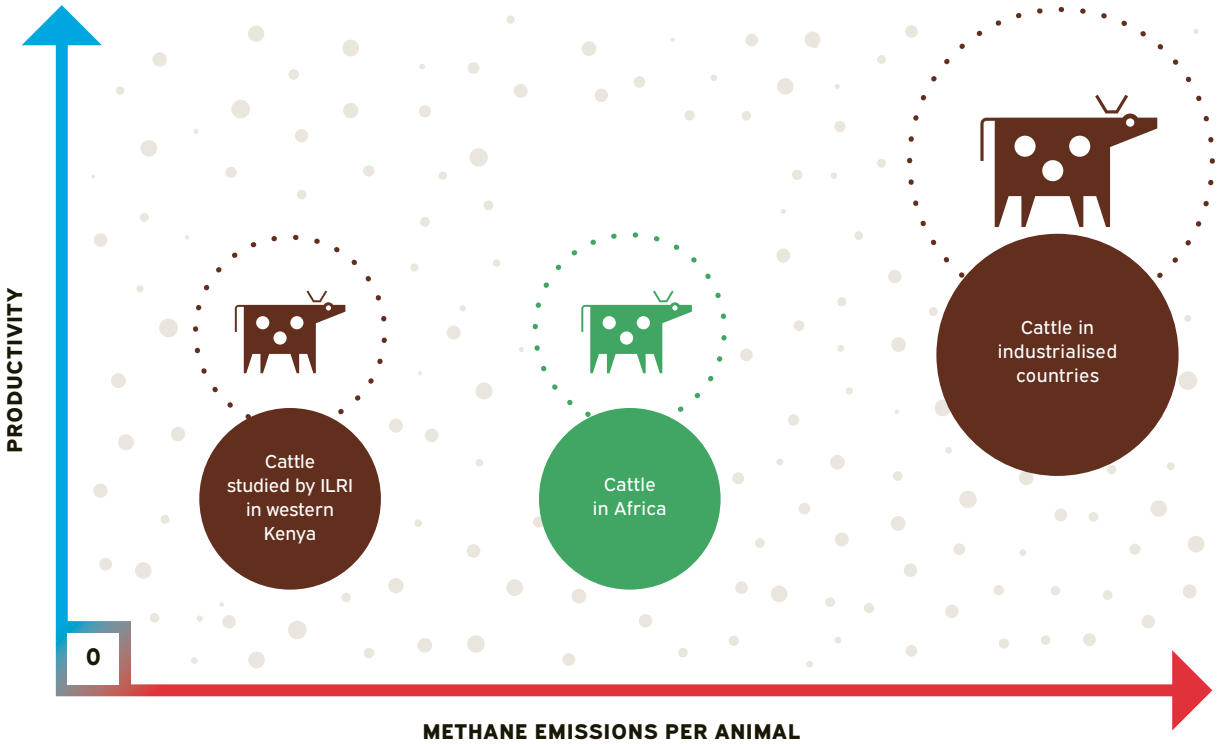
These uncertainties arise because the Tier I protocol extrapolates emission factors based on studies that almost exclusively examine western, industrialised systems where animals are raised to maximise productivity of a single output (meat, milk, etc.) in isolation from the wider

environment. It then adjusts them for extensive low- and medium-income systems with very little *in situ* data to corroborate or challenge them (Goopy *et al.* 2018; Alibés *et al.* 2020). These industrialised systems are mostly high-intensity dairy and beef farms, with different breeds, feed, management practices, climatic regions and landscapes to those found in tropical extensive systems (ILRI 2018). One example is the widely used Global Environmental Assessment Model (GLEAM),[28] which estimates emissions for extensive systems based on general emission factor rates, resulting in sometimes questionable results.[29]

Recent empirical studies have found that the IPCC Tier I protocol overestimates emissions from African pastoral landscapes. For example, a study by Zhu *et al.* (2020b) found the nitrous oxide emissions from the manure of extensive cattle in Kenyan savannas to be up to 14 times lower than the IPCC Tier I estimate. A study by Assouma *et al.* (2019a, 2019b) in the Ferlo region of Senegal measured the daily feed intake of ruminants over the course of one year. The results showed that the current standard reference intake amount from the IPCC used in emissions calculations (25 g dry matter/kg live weight) is probably too high for all of Africa. The authors proposed a new standard of either 18 g dry matter/kg live weight for cattle and 34 g/kg live weight for small ruminants, or 73 g/kg metabolic weight for all ruminants (Assouma *et al.* 2019a). The *in situ* emissions values collected are also substantially lower than the IPCC default (see case study below). When focusing on emissions from manure, most assessments do not currently have such field-level data and use constant livestock excretion rates where dung is assumed to be distributed uniformly. Further uncertainties arise in relation to the proportion of the manure that is managed and the emission factors for nitrogen used may not reflect the context of most extensive livestock production systems (Rufino *et al.* 2014).

Methane emissions and per-animal productivity: directly measured and estimated

Figure 4. Source: ILRI (2018)



The Tier II protocol used by more recent studies is an improvement, as it takes account of the live weight of different livestock. Emission factors are based on feed intakes using metabolism algorithms. Research by Kouazounde *et al.* (2015), investigating methane emissions from enteric fermentation in Benin using the Tier II methodology, found large discrepancies between their results and the Tier I estimates. Preliminary Tier II results from *in situ* data collected in Kenya showed that enteric CH_4 emissions in small-scale livestock systems were up to 40% lower than Tier I estimates. Furthermore, emissions from manure and urine applied to soils in Western Kenya were 50% (CH_4) and 90% (N_2O) lower than Tier I (ILRI 2018; Goopy *et al.* 2018). Using the Tier I protocol therefore consistently overestimates carbon emissions by animals in extensive systems, especially in poorer countries with the need for region-specific and practice-specific estimates (cf. Leitner *et al.* 2020; Marquardt *et al.* 2020).

However, even the Tier II protocol makes some inappropriate assumptions when used for extensive, low-input systems (Goopy *et al.* 2018). Tier II estimates enteric CH_4 emissions based on feed intake and diet quality, with putative feed intake back-calculated on the basis of algorithms of energy digestibility and metabolisable energy partitioning (between maintenance, growth, thermoregulation, pregnancy, movement and lactation). These algorithms are based on experiments carried out in the northern hemisphere with animals contained in respiration chambers (IPCC 2006). Such conditions clearly do not effectively replicate extensive grazing systems, as the calculations assume that food intake by animals is constant and unrestricted, yet in smallholder farms cattle are typically penned overnight, with food intake limited during this time (Goopy *et al.* 2018). Also, in estimating metabolic energy requirements, the methodology assumes animals grow at a steady rate throughout the year. While this might be true in a more intensive, high-input system, where cattle are bred to maximise productivity, this is not characteristic of seasonally variable, extensive, low-input systems. Ruminants fed on tropical pastures tend to lose weight during the dry season due to feed shortages and to grow faster during the wet season when there is abundant feed (Goopy *et al.* 2018). Equally, the mobility of pastoral herds may also mean that animals lose weight during transhumance (Wagenaar *et al.* 1986). While more accounts of region-specific differences and different animal classes are emerging,[30] models that continue to assume stability and uniformity in livestock systems ignore the importance of variability, the very basis of production in a non-equilibrium system, especially in pastoral settings (Krätli *et al.* 2015).

Defining the system

What is 'efficient'?

Policy discourses around the sustainability of livestock systems are often centred on improving production efficiency of particular products, notably meat and milk. The mainstream productivist idea of efficiency is framed as maximising output and minimising negative impact per unit of input (Garnett *et al.* 2015). Wider notions of efficiency encompass not just inputs but the relationship to undesirable outputs, such as GHG emissions, soil degradation, water pollution and land use change. Following such conceptualisations of efficiency, some argue that livestock production is inherently inefficient (Box 4).

Problematic narratives of livestock 'inefficiency'

Box 4

Livestock eat food and exploit land that humans could use (Garnett et al. 2015), and they consume more food than they produce
(Wirsenius *et al.* 2010; Cassidy *et al.* 2013; Searchinger *et al.* 2019).

83% of agricultural land is used for animal agriculture, but animal-sourced foods (including aquaculture) provide only 18% of global calories and 37% of protein
(Poore and Nemecek 2018).

Livestock are an inefficient use of land. Animal agriculture takes up 77% of all agricultural land, while providing only 17% of global food supply.[31]

The inefficient use of land by animal agriculture, combined with fast-rising demand for animal-source food, has driven vast agricultural expansion and damage to land-based ecosystems and biodiversity.

However, livestock have many uses other than the production of animal products: livestock are a source of savings, a form of insurance, the basis for marriage exchanges and a source of draft power, transport and fertiliser, among many other things. In other words, they are multi-functional. This requires a more sophisticated approach to assessment (Weiler *et al.* 2014; Mazzetto *et al.* 2020). Focusing only on animal products means extensive livestock farming systems have been branded as the least efficient, as more food is needed to achieve a unit of product, more time is needed for animals to reach slaughter weight and more land is needed per unit output (Alibés *et al.* 2020). Many extensively reared ruminants also have higher levels of emissions per unit output attributed to them (Clark and Tilman 2017). For example, grass-fed beef has higher land use requirements than grain-fed beef, and emits an average of 19% more GHGs per unit of product (Clark and Tilman 2017). Some argue that the solution lies in engineering a low methane-emitting ruminant, but the possibilities of this seem remote and instead mitigation efforts should work with existing systems to reduce emissions (Goopy 2019).

However, and focusing only on animal products, extensively used areas are assumed not to reach maximum 'productivity', with one study suggesting that less than 20% of 'potential' is achieved (Stehfest *et al.* 2009). Shifts to organic production of livestock do not always improve efficiencies in these terms either (Meier *et al.* 2015; Smith *et al.* 2019). Yet, none of these assessments reflects on 'efficiency' in a broader sense beyond a narrow productivist lens, looking for example at the wider environmental and nutrition benefits of extensive livestock production. Nor do such assessments treat over-production or over-consumption (according to dietary recommendations) as an inefficiency, and so ignore wider economic and health costs of certain styles or production. LCAs, for example, do not weigh output against any upper limit on need, thus biasing results in favour of industrial systems. By failing to differentiate between different types of 'protein' and the specifics of dietary requirements, such biases are further reinforced (Lee *et al.* 2021; Moughan 2021).

Perhaps the major flaw in these 'efficiency' measurement parameters, though, is equating the food that grazing animals eat to the food that grain-fed animals eat. Even though they use less land per unit of product, industrial farms use land for feed that could be used for crops (McGahey *et al.* 2014). More intensive systems are associated with deforestation for growing feeds, such as soy bean. On the other hand, extensive grazing systems can produce food without the need for synthetic nitrogen inputs, with legumes fixing nitrogen, for example. Importantly, grazing animals eat substances that are inedible to humans, and marginal lands unsuitable for crop production cannot be converted into arable areas (Garnett *et al.* 2017; Mottet *et al.* 2017a, 2017b; Adesogan *et al.* 2020; Alibés *et al.* 2020; Sahlin *et al.* 2020). Therefore, pastoral and other extensive livestock grazing systems can be highly 'efficient' in that they allow for the use of heterogeneous, marginal landscapes and resources and do not use concentrated, grain-based inputs that compete directly with crops for human consumption (Manzano and White 2019).

Mobile grazing practices on marginal lands also optimise the use of limited resources, matching the presence of animals with annual peak resource productivity (Krätli 2015). The outcomes on ecosystems and biodiversity are also radically different between production systems: while at one extreme crop agriculture drastically reduces biodiversity, at the other extreme mobile, extensive pastoralism mimics the grazing and seed dispersal patterns of wild migratory herbivores, positively influencing biodiversity (Manzano-Baena and Salguero-Herrera 2018), pollinator populations (García-Fernández *et al.* 2019) and tree regeneration (Carmona *et al.* 2013). Avoiding land fragmentation and enhancing mobility, therefore, can have major positive impacts on ecosystems.

It is thus extremely important to differentiate between types of land when assessing livestock's environmental impact, as not all grazed land can be converted to cropland (ASAS 2019). Considering efficiency from this more nuanced angle, extensive systems can be viewed in a very different light. The current mainstream conceptualisation of efficiency has thus been criticised as too simplistic and reductive to be globally applicable, as it fails to encompass "differences in the qualities of resources used as inputs, the types and multiplicity of outputs generated and their irreducible interconnectedness" (Garnett *et al.* 2015: 5). This is especially so when assessing extensive grazing systems. Overall, systematic comparisons across production systems show that unfertilised grass-fed production where land clearance does not occur may have significant advantages over intensive stall-fed

Travel eastwards to mainland Gujarat. Photo: Nipun Prabhakar

production if a wider array of factors are included – although of course mitigation measures are still required (Pierrehumbert and Eshel 2015).

What is measured also makes a difference. The LCA approach to emission estimates is heavily focused on animal-level emissions, or emissions per unit of product. Units of measurement include per unit weight, per serving, per unit of energy, per unit of protein and per unit of primary nutritional benefit (Poore and Nemecek 2018; Willett *et al.* 2019). Concentrating on animal-level emissions externalises the natural environment and fails to capture the complexities of environmental interactions. As a result, LCA studies do not give a full picture of livestock's impact (Herrero and Thornton 2013). This is especially true for pastoral systems, where livestock is deeply integrated into the local ecosystems and landscapes.

As a result, the standard metrics used skew the results against extensive animal farming due to the comparatively low output per animal of more extensive systems. For pastoral systems, animal emissions from manure and enteric fermentation are the only substantial emissions, while livestock offer other ecosystems services, such as pasture management, fire prevention, flood protection, biodiversity conservation or transferring fertility to the soil (Alibés *et al.* 2020). Taking account of a wider diversity of impacts – positive and negative – can offer a different picture (Garnett 2017). As we discuss further below, a more comprehensive ecosystems approach is needed to contextualise extensive livestock production within the local landscape and accurately assess the carbon footprint.

Livestock and the carbon cycle

Key assumptions made in LCA studies are that soil carbon balance is in long-term equilibrium (Rowntree *et al.* 2020), and that livestock add additional emissions to an otherwise balanced carbon cycle. As a result, most assessments do not include carbon sequestration in their analyses. However, when studies of extensive livestock systems adopt an ecosystem approach and include sequestration from grazing, the carbon balance has been found to be neutral in those cases where degraded soils are restored through livestock grazing practices (see below).

"Climate-damaging ways of life are concentrated among a 'consumption elite', often rich people in rich countries."

Carrying winter fodder in Amdo Tibet. Photo: Palden Tsering

Rangelands contain some of the most substantial reservoirs of soil carbon and have high sequestration potential, depending on patterns of grazing (Herrero *et al.* 2016; Zhou *et al.* 2017) and on whether climate change is likely to reduce or enhance primary productivity (Boone *et al.* 2018). Good grazing practices can help maintain soil carbon stocks and even increase them in some contexts (Garnett *et al.* 2017; Fairlie 2018).[32] Livestock are important in mediating soil carbon levels, something that LCAs often omit from their analyses (Rowntree *et al.* 2020). The mobility of pastoral herds gives rangeland time to regenerate, with pastoralists moving their herds to maximise the use of the limited resources available (Conant *et al.* 2017). When considering alternatives and appropriate baselines (see also below), many studies have found that continuous use results in substantial reductions in soil carbon (McSherry and Ritchie 2013)[33], whereas mobile, light grazing can in fact be beneficial. Conversion of rangelands to cropping can be especially damaging. For example, a study by Han *et al.* (2008) found that there was a 22% reduction in soil carbon stocks when pastoral grazing land was converted to cropland in Inner Mongolia. Other grazing systems aim to mimic natural herbivore grazing, with high levels of focused disturbance in rotation and (disputed) claims of climate benefits (Savory 2017).

However, the carbon storage potential in pastoral ecosystems remains poorly understood, resulting in an assumption that there is little potential for substantial carbon stocks within them (Dabasso *et al.* 2014). Any attempt to estimate carbon stocks often assumes uniformity across a complex rangeland ecosystem. Pastoral landscapes are highly heterogeneous in terms of microclimate, physical landforms, rainfall and seasonal differences in primary productivity (Ayantunde *et al.* 1999; Schlecht *et al.* 2006; Hiernaux *et al.* 2009; Dabasso *et al.* 2014). This means carbon stocks are distributed unevenly by an order of magnitude or two within landscapes and are not fully captured when homogeneity of the system is assumed, which often leads to underestimates of carbon stocks in rangelands (Dabasso *et al.* 2014).

A wider systems approach (Dabasso *et al.* 2014; Assouma *et al.* 2018a, 2018b, 2019a, 2019b) highlights the need to differentiate between baseline emissions from the natural carbon cycle and any extra emissions from livestock in order to establish the real impact of domestic livestock (Alibés *et al.* 2020). While the assumptions surrounding soil carbon may be reasonable for industrialised, high-input systems that are spatially and temporally homogenous, this is not the case for highly dynamic extensive livestock systems. The result is frequently overestimates of emissions from such settings. As we discuss further below, a wider ecosystem approach is needed to factor in the natural carbon cycle and carbon sequestration in rangelands.

Changes over space and time

Not all farming is static and settled, but assessments do not sufficiently take into account either the movement of people and their animals, or the transfer of nutrients between sites. Aggregated LCA assessments often calculate a net balance for a particular farm or other bounded area, without looking at what happens over time and across space. Designed for contained, industrialised systems, the approach often misses important variability, which has implications for approaches to mitigation. This is especially important in highly variable, extensive rangelands, where quite different carbon and nitrogen fluxes may occur to croplands (Pelster *et al.* 2016), especially where crop intensification involves fertiliser additions (Leitner *et al.* 2020). Studies show how CO_2 fluxes are higher in enclosed areas compared to open grazing, as there is often more moisture and soil organic matter and so increased respiration (Oduor *et al.* 2018).[34]

Within a variable, extensive rangeland, there may be particular emissions 'hotspots'. These will be dependent on the movement of animals, their resting behaviour and the pattern of deposition of faeces and urine (Pelster *et al.* 2016; Leitner *et al.* 2021; Zhu *et al.* 2021). For example, faeces/urine deposition sites near shade trees; temporary pools and ponds where animals come to water; *kraal* and *boma* areas where animals are kept at night; and other 'key resource' grazing areas, such as low-lying wetlands within drylands (Scoones 1991; Butterbach-Bahl *et al.* 2020), may all have high net emissions. By contrast, other rangeland areas may have uptake of carbon due to sequestration processes. Such emissions hotspots may also persist over long periods of time, with the signals of former livestock pens evident over centuries (Muchiru *et al.* 2009; Marshall *et al.* 2018).

Carbon and nitrogen fluxes are therefore highly site-specific and vary over time, with high levels of contextual

variability (Ali *et al.* 2021; Carbonell *et al.* 2021). Emissions may be higher in the hotter, wet season when processes of oxidisation and mineralisation occur faster, but may slow down at other times of year. In certain periods, including just before the rains, there may be important nutrient flushes in some savanna woodlands creating potential 'sequestration hotspots' as animals switch their feeding patterns, while rewetting after a long dry spells may result in emission peaks (Leitner *et al.* 2017). Across years, fluxes shift as rainfall amounts change, with lower emissions in drier years or when animals disperse across wider areas due to movement, reducing the concentration effects in particular hotspots.

Such variability emerges from the non-equilibrium dynamics of many pastoral ecosystems, where interactions between soil fertility and rainfall generate a particular type of nutrient dynamics in both soils and grasses, and so affect herding patterns and in turn feeding behaviours (Penning de Vries and Djiteye 1982; Ellis and Swift 1988). Such dynamics will look very different in contrasting dystrophic and eutrophic soil types (Behnke *et al.* 1993; Frost *et al.* 1986).

The standard list of mitigation measures that are proposed to address livestock-based emissions (see above) should be adapted to the contexts of extensive livestock settings. Adjusting herding patterns, revising manure management strategies and changing seasonal feed intake may all make a difference, but must be highly attuned to the extensive, sometimes mobile setting. Mitigation potentials do exist in extensive systems, but the system needs to be understood properly first. Simplistic recommendations that assume a transition to an 'efficient' industrial model are seriously misplaced – and are likely to be counterproductive.

Ecosystem services

Taking into account ecosystem services shows the wider effects of pastoral of extensive grazing systems that current assessments tend to neglect (D'Ottavio *et al.* 2018). The majority of LCA studies prioritise the assessment of a limited number of environmental indicators, i.e. GHG emissions and land use, reflecting the limited data available for other factors such as biodiversity and ecotoxicity (Clark and Tilman 2017; Sahlin *et al.* 2020). LCAs therefore often fail to integrate the diverse interactions (both positive and negative) between livestock and the ecosystems they encounter into their analyses, and they often do not account for the myriad of ecosystem services that well-managed livestock can offer in a pastoral context.

Some examples of ecosystem services attributed to pastoral grazing include: rangeland maintenance, which maintains sequestration potential in soils and vegetation; nutrient cycling, which eliminates the need for synthetic fertiliser; soil health maintenance; landscape biodiversity promotion through seed dissemination, species conservation, plant species control and regeneration; habitat preservation; provision of human and animal food; wildfire prevention; water cycle regulation; and cultural services through tourism, cultural identity and traditional knowledge (Assouma *et al.* 2018a; Paul *et al.* 2020; Russell *et al.* 2018). All add up to substantial environmental and conservation benefits of particular types of livestock production that should be taken into account.

As discussed further below, a systems approach more effectively integrates these factors into any analysis,

Selling milk by the roadside, Borana. Photo: Masresha Taye

addressing the landscape as a whole, and is thus more suitable for assessing complex, variable, extensive systems.

Baselines and alternatives

Alternative land uses

What would replace livestock? An assumption of many LCA assessments is that the abandonment of livestock rearing – especially extensive systems – would result in beneficial rewilding/regeneration of the land, allowing for more effective carbon sequestration. Tree-planting and other 'ecosystem restoration' initiatives are frequently envisaged as an alternative to livestock production, creating in accounting terms a 'carbon opportunity cost' of not removing livestock and switching to plant-based diets (Hayek *et al.* 2021).

However, such studies ignore the potentials of carbon sequestration on grasslands and the challenges of many 'restoration' efforts in pastoral areas, notably tree-planting (Fleischman *et al.* 2020; Ramprasad *et al.* 2020). Studies have shown how grasslands, due to their extensive root systems, may have even higher carbon sequestration potential than trees and, with regular 'cool' burns, are safer from fires as carbon stores. Analysing experiments on plant/root growth and sequestration due to increases in CO_2, Terrer *et al.* (2021) conclude that the high carbon stocks in grasslands have great potential to accumulate more soil carbon as CO_2 levels increase, with plant biomass growth being inversely related to the accumulation of soil carbon. This is contrary to many assumptions that the optimal climate mitigation response is the expansion of afforestation rather than the encouragement of sequestration in grasslands (Bastos and Fleischer 2021).

Arguments for 'land-sparing' approaches that advocate intensification of production to release land for other uses (cf. Lusiana *et al.* 2012; Lamb *et al.* 2016; Folberth *et al.* 2020), including biodiversity protection and afforestation, should therefore be qualified. Clearly, reducing deforestation due to the expansion of livestock rearing in areas such as the Amazon is essential (Cohn *et al.* 2014) but, in other areas where grasslands are long-established, such approaches are much more questionable, especially given livestock's contribution to creating and maintaining biodiversity. Calls to protect 30% of land areas for biodiversity, create a global biodiversity 'safety net' or commit to a 'half-earth' conservation approach (Wilson 2016; Dinerstein *et al.* 2020) have been widely criticised (Kothari 2021; Pascual *et al.* 2021). They could massively undermine sustainable, extensive land uses such as pastoralism, especially when such initiatives involve afforestation of rangelands, so reducing space for livestock production.

> **"All this means bringing pastoralists and other low-input, extensive livestock producers – and the organisations that represent them – into global debates on climate change and the future of food systems."**

Niche replacement

Current LCA literature advocating for the abandonment of livestock rearing makes some key assumptions regarding what will happen to land abandoned by livestock for rewilding or regeneration. The assumption is too often that the alternative to grazed landscapes is closed forest but, outside rainforests such as the Amazon, this is not the case, as most ecosystems are grazing-dependent, including open forests, parklands, savannas and tundra (Bond 2019). If livestock are removed, the niche will most likely be filled by another methane-producing herbivore (Manzano and White 2019; Alibés *et al.* 2020), whether wild ruminants or termites (Deryabina *et al.* 2015). Extensive livestock systems making use of grasslands (often as patches within wooded ecosystems) therefore replicate 'natural' or 'wild' systems.

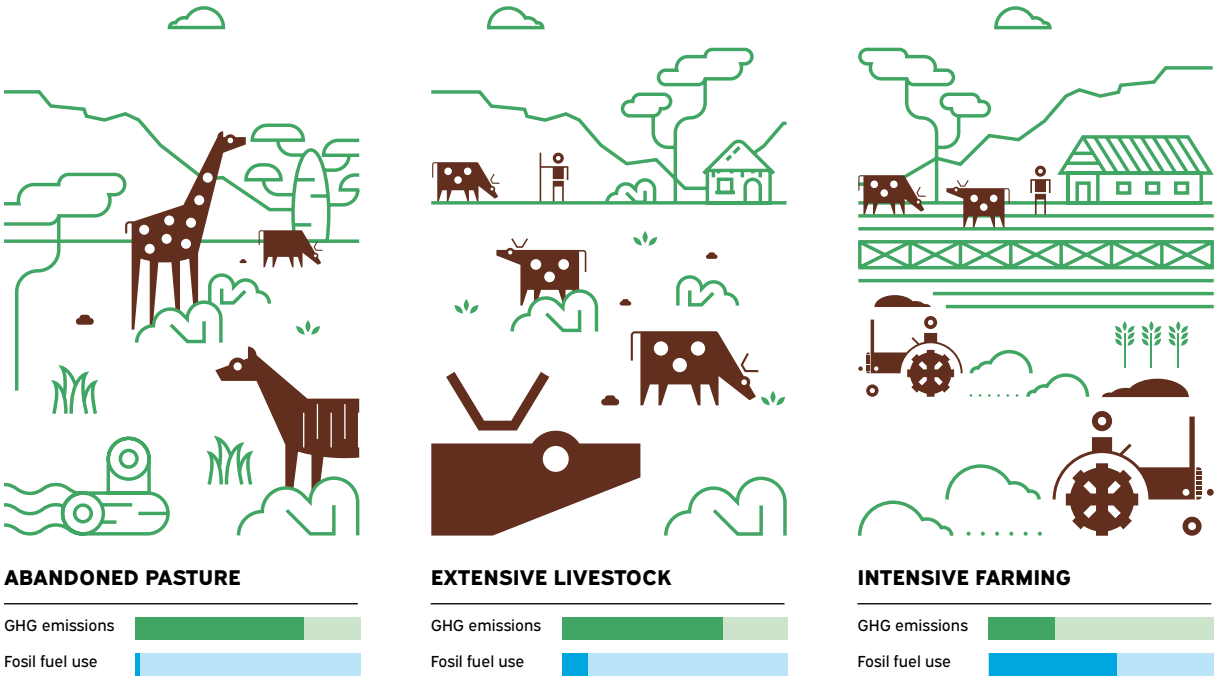
This makes assessing baselines crucial, as livestock may not add to 'natural' emissions (as is assumed in standard LCA measures and climate scenarios). Removing livestock may have negative impacts on biodiversity too, as most ecosystems have co-evolved over millennia with herbivores. Following the extinction of many megaherbivores, livestock have been important in most landscapes, outside the limited areas of truly closed forest (mostly rainforest), maintaining ecosystems and reducing fire impacts (Bond 2019). As a result, excepting the highly damaging clearance of closed rainforest areas for grazing or for the growing of feed, the impacts of land use change from extensively grazing livestock in open forest-mosaic and savanna landscapes may be less than is frequently assumed in standard land use and land-cover change assessments driving climate scenarios, as livestock have long been an important part of most of the world's terrestrial ecosystems (Manzano and White 2019).

Before domestic livestock occupied United States rangelands, wildlife has been estimated to produce around 86% of existing emissions (Kelliher and Clarke 2010; Hristov 2012), a figure potentially higher if pre-human megafauna are included (Smith *et al.* 2016). Estimates of emissions from termites are uncertain, but can also be significant (Collins *et al.* 1984; Spahni *et al.* 2011). In African savannas, for instance, the biomass of termites is greater than that of ruminant livestock, with correspondingly higher leaf matter consumption (Huntley and Walker 1982). Shifts in herbivore composition can also have impacts on the risk of wildfires that emit vast quantities of GHGs, including methane (Alibés *et al.* 2020). The complete abandonment of livestock production in certain extensive contexts could therefore have negative impacts on landscape-level emissions (Manzano and White 2019).

Current practice using LCAs to derive emissions estimates usually do not consider such baseline conditions, whether shifts following advocated removal of livestock resulting in a return to 'wild' ecosystems or shifts to intensified agriculture. This results in large distortions in the interpretation of results, with major implications for policy (Manzano and White 2019; see Figure 5).

Comparing greenhouse gas emissions per animal across systems

Figure 5. Source: Manzano and White (2019)



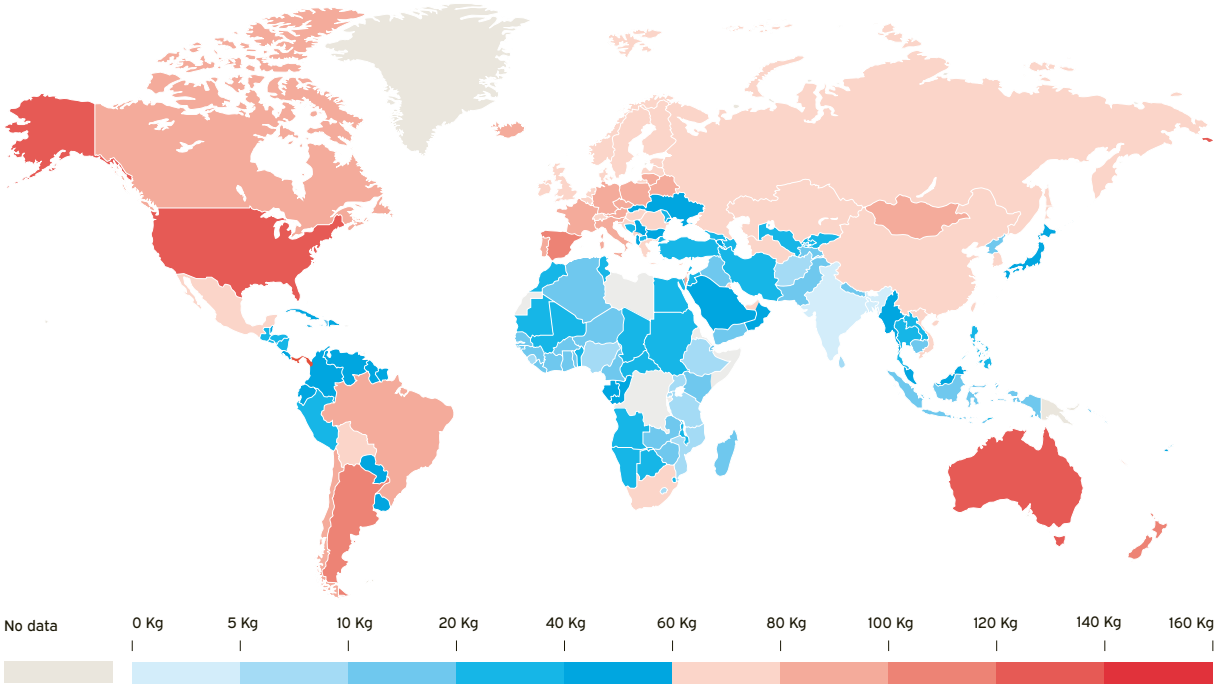
Consumer choice and dietary patterns

How might diets change, and what would be the consequences? LCAs often make assumptions about what will replace meat in alternative dietary scenarios. These scenarios often substitute meat with high-yielding, low-impact, minimally processed plant foods such as maize, wheat, pulses, fruits and vegetables (Hallström *et al.* 2015; Searchinger *et al.* 2019; Willett *et al.* 2019). However, plant-based diets based on people's own choices tend to have higher environmental impacts than the hypothetical dietary scenarios of most LCA assessments (Vieux *et al.* 2012). Estimated impacts of diet change away from red meat on total GHG emissions are extremely variable, ranging from 3% to 28% emission reductions in recent studies (Aston *et al.* 2012). Studies also show that an individual's lifetime climate impacts may be reduced by only 2-4% through switching away from meat to a more plant-based diet, with potentially damaging nutritional consequences (Barnsley *et al.* 2021).

Plant-based foods also have their own varied costs and limitations. Highly processed, plant-based meat replacements such as mycoprotein, tofu and tempeh are increasingly present in modern plant-based diets, and their environmental impact is likely to be higher than unprocessed plant foods due to the high-energy demands of processing and transport (Hallström *et al.* 2015). For example, a study by Smetana *et al.* (2015) found that producing 1 kg of mycoprotein had a similar environmental impact to producing 1 kg of chicken, with 45% of this coming from processing. The study also found the GWP of mycoprotein to be 5.55 kg–6.15 kg CO_2-eq per kg product, compared to 2 kg–4 kg CO_2-eq per kilogramme of meat for chicken and 4 kg–6 kg CO_2-eq of meat for pork (Smetana *et al.* 2015). While there is much hype about the potentials of cultured meats, linked to considerable vested commercial interests,[35] the possibility of their replacing animal-source foods is remote, particularly in poorer countries.

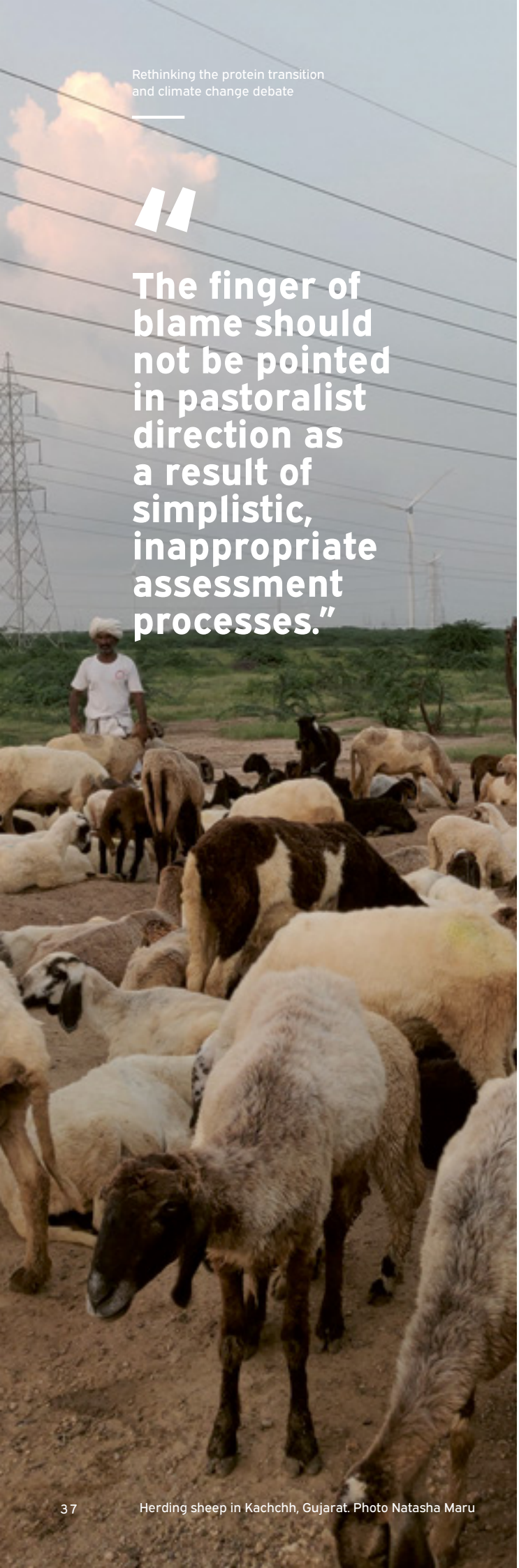
Meat supply per person

Figure 6. Source: Our World in Data, from FAO (2017)



NOTE

Data excludes fish and other seafood sources. Figures do not correct for waste at the household/consumption level so may not directly reflect the quantity of food finally consumed by a given individual.



> **"The finger of blame should not be pointed in pastoralist direction as a result of simplistic, inappropriate assessment processes."**

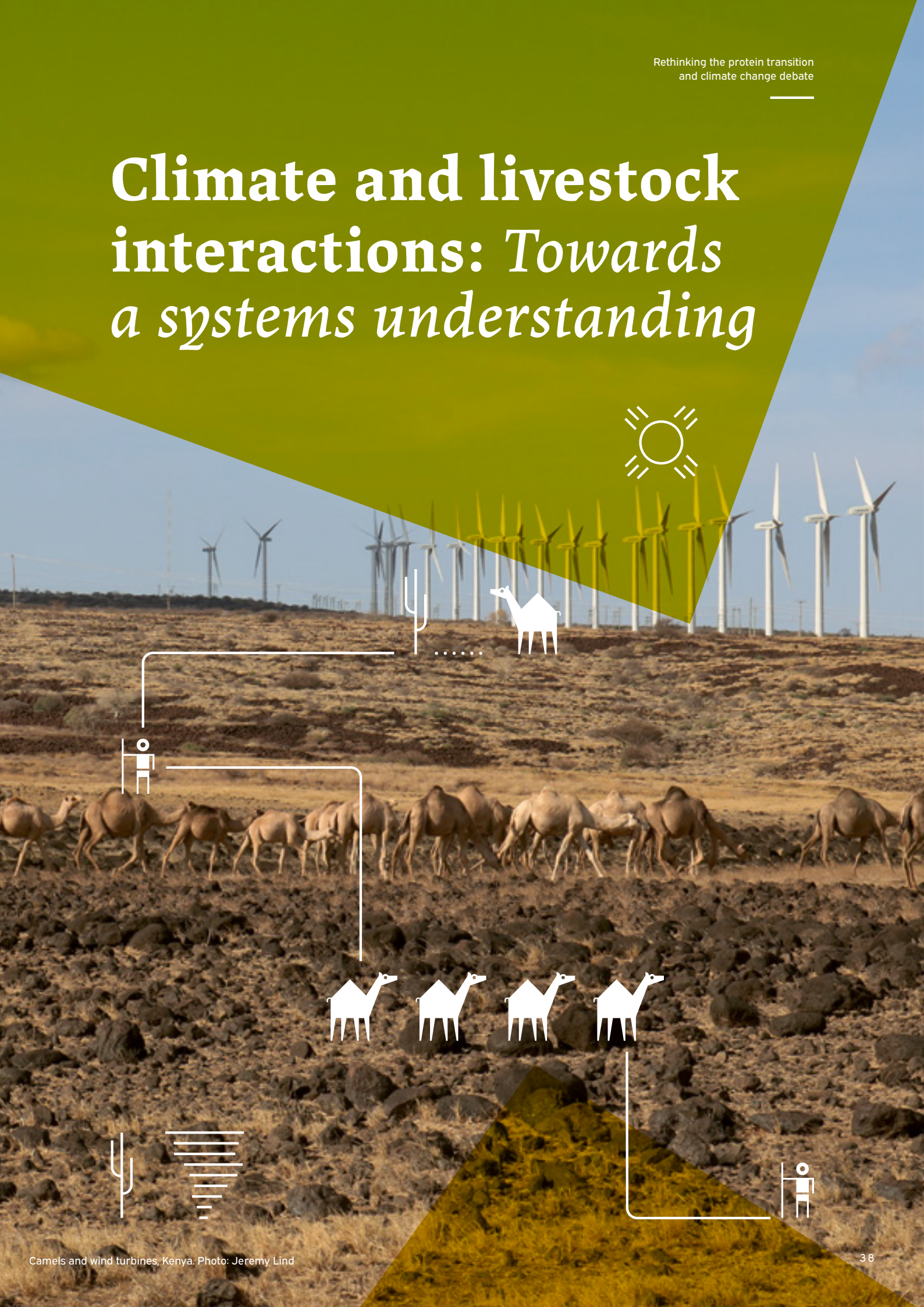
In many other countries, gaining access to a limited amount of meat or milk is essential for nutrition, especially for those requiring high levels of nutritional supplements, such as young children, pregnant women and those who have various illnesses (Alonso *et al.* 2019). As Adesogan and colleagues argue, the EAT–Lancet approaches "overestimate and ignore the tremendous variability in the environmental impact of livestock production, and fail to adequately include the experience of marginalised women and children in low- and middle-income countries whose diets regularly lack the necessary nutrients" (Adesogan *et al.* 2019). Despite the prevalent media focus on excess consumption and the need to change diets, many people across the world do not have access sufficient animal-sourced food to meet their needs. Patterns of meat production are highly unequal across the world (Figure 5), and important questions of costs and affordability of reference diets have been raised (Hirvonen *et al.* 2020). Questions of equity and rights are therefore important in a balanced approach to diet change, rather than simply a focus on boundaries and limits (Fanzo *et al.* 2017; Béné *et al.* 2020).[36]

To date, the actual environmental impact of processed meat substitutes has not been widely investigated, and few LCA studies have included them in their hypothetical scenarios (Hallström *et al.* 2015; Godfray 2019; Chriki and Hocquette 2020). Moreover, it is likely that people foregoing meat will increase their dairy consumption, which has its own implications for sustainability (Nordhagen *et al.* 2020). A focus on specific nutrients, rather than generic 'protein', offers a different picture, as livestock produce high-density protein sources with an appropriate balance of nutrients for human consumption (Lee *et al.* 2021; Moughan 2021). Achieving this from a purely plant-based diet is more challenging.

In sum, LCA studies with unrealistic hypothetical diet scenarios run the risk of overestimating the potential benefits of reducing meat consumption (Searchinger *et al.* 2019). Realistic consumption patterns need to be included in plant-based hypothetical dietary scenarios in order to gain accurate projections for dietary shifts. That said, reducing meat consumption from low-quality industrial sources must remain a priority. This would have benefits for human health and animal welfare, as well as for the climate. The key point is to differentiate between livestock systems, as well as health priorities and dietary needs.

Herding sheep in Kachchh, Gujarat. Photo Natasha Maru

Climate and livestock interactions: *Towards a systems understanding*



Camels and wind turbines, Kenya. Photo: Jeremy Lind

So how bad are livestock for the planet, and how do we know? The availability and accuracy of the data, the way systems are defined and what baselines or alternatives are assumed make a big difference to assessments of livestock's impacts on climate change. The generalised narrative that 'all livestock and meat are bad' needs to be qualified. Taking a different framing of the system, more accurate and complete data and different baselines into account means that extensive pastoral systems may not be as bad for the climate as is often assumed.[37]

Our review of the existing methodological practice around LCAs points to the need to change the assessment approach, or at least to move away from using aggregated results that point to universalised and simplistic policy prescriptions, focusing on narrow definitions of efficiency and sustainability. Persisting with such approaches – a continuation of a longstanding focus on productivist perspectives from the colonial era onwards – may result in inappropriate policies that may affect millions of pastoralists and other livestock keepers across the world's extensive rangelands, without addressing the core challenges of climate change effectively.

What do more focused analyses of extensive livestock production suggest, and what alternative methodological approaches might be proposed? This section focuses on three cases – from Europe, Asia and Africa – that have adopted a more sophisticated approach and adapted it to a pastoral setting. Together, they suggest the need to adopt a systems approach to assessment that adapts and extends the LCA methodology, while differentiating between contrasting contexts. Only with such a shift in approach will we get beyond the simplistic and misleading policy messages emerging from much research on the livestock–climate nexus.

Artisanal cheese production, Sardinia, Italy. Photo: Ian Scoones

Case 1: Sardinia, Italy

Sardinia contributes to about a quarter of the European Union's sheep production, with over 3 million ewes distributed across 14,000 farms. During the 1980s, the pastoral production system intensified as the price of sheep milk was high, thanks to the boom of the Pecorino Romano cheese export trade. Subsidies further encouraged the development of irrigated fodder production in the lowlands, while transhumant extensive pastoralism in the mountains declined. This pattern was reversed in recent decades, as milk prices dropped and a pattern of extensification returned. Over the last few years, the Sheep2Ship project has been investigating the impacts of these two very different types of livestock production on the wider environment, as well as on GHG emissions (Vagnoni *et al.* 2015; Vagnoni and Franca 2018).

Comparing the situation in 2001 (intensive) and 2011 (semi-extensive), a LCA was applied to sheep farms in Osilo region of northwestern Sardinia (Figure 6). In 2001, the system was geared to both milk and meat, but by 2011 it had shifted almost exclusively to milk production. The carbon footprint of both systems at farm level was similar, being respectively 2.99 CO_2-eq and 3.25 CO_2-eq per kilogramme of final product (fat and protein corrected milk). In both periods, enteric methane resulted in around half of all GHG emissions. Similar results have been found in other Mediterranean systems, including in northern Spain (Batalla *et al.* 2015), as well as elsewhere in Sardinia (Atzori *et al.* 2014).

The more recent system was only semi-extensive and still used significant imported feeds, including soy, protein pea and cereals. Where fodder is imported from outside, particularly when coming over long distances as with soybeans, the carbon footprint increases significantly. In 2001, soybean dominated the feeding system, while by 2011 the use of harvested hay and natural grazing was more common. The more intensive system additionally had higher fossil fuel costs, although local transportation of artisanal products was seen to be inefficient.

Looking across studies from this region, however, there are huge variations in emissions estimates. This is due both to the factors used in calculating CO_2 equivalents from methane emissions, as well as to real differences in emissions depending on the fodder consumed by the animals. However, across these particular studies in Sardinia, contrary to the mainstream assumption that extensive systems generate more emissions per product amount, the differences in on-farm emissions between intensive and semi-extensive systems were not significant.

Taking a broader view, another study has examined the contrasts in emissions between value chains, contrasting the industrial production of Pecorino Romano PDO via a co-op with the more artisanal Pecorino di Osilo PO, produced on-farm as a family business (Vagnoni *et al.* 2017). Across the chain, the production element contributed 92% of emissions, while cheese processing and distribution contributed the remainder. Distribution emissions were marginally higher for the artisanal production, given the small distances and regular travel involved. This research, however, did not include the potentials for carbon sequestration and the value of ecosystems services generated especially by the more extensive system. As other studies show (Ripoll-Bosch *et al.* 2011; Feliciano *et al.* 2018), this can have a major impact on the assessment, given the array of ecosystem benefits of extensive systems, as shown across European pastoral systems (Torralba *et al.* 2018).

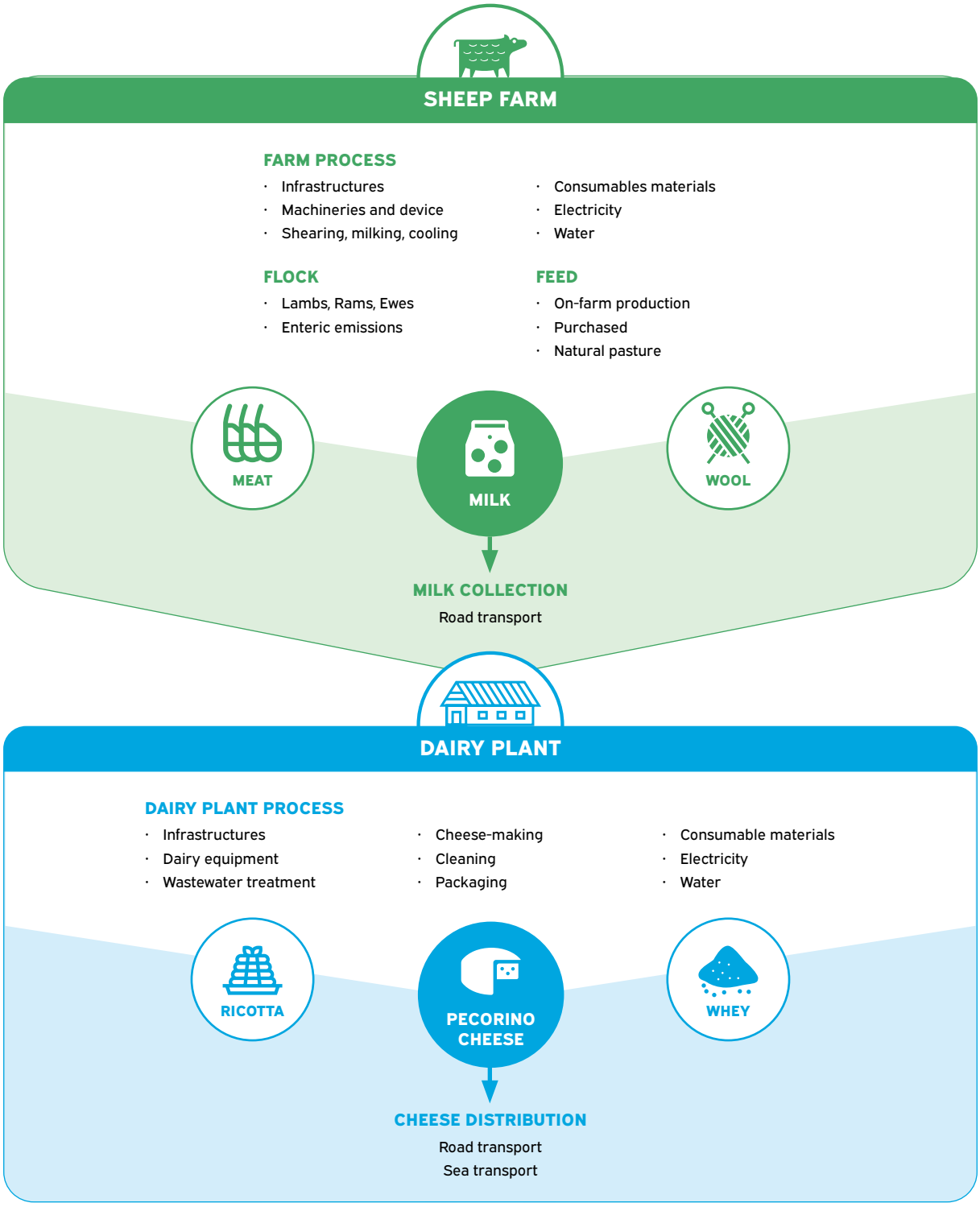
This is highlighted in particular when carbon sequestration is accounted for. A recent LCA study included sequestration in temporary and permanent grasslands (Arca *et al.* 2021). The study showed that the semi-extensive system has a strong potential for offsetting GHG emissions through sequestration in permanent grasslands. When soil carbon sequestration was included, the study showed slightly lower GHG emissions per kilogramme of milk in the semi-intensive production system (from 3.37 CO_2-eq to 3.12 CO_2-eq per kilogramme), but the reduction was higher in the semi-extensive system (from 3.54 kg to 2.90 kg CO_2-eq per kilogramme).

In addition to emphasising the importance of extensive systems and highlighting the potential for carbon sequestration in permanent pastures, mitigation interventions identified include reducing enteric methane fermentation through shifting feed supply, supplying inhibitors and rumen control modifiers and grazing management, as well as tackling the feed supply chain (Marino *et al.* 2016). However, although changes in feed management might offer an apparent reduction in GHG emissions by reducing methane, it may greatly

increase the fossil fuel footprint and create land use change related emissions far away, where the protein-rich fodder is planted (del Prado *et al.* 2021). Again, the bounding of the system makes a big difference to the conclusions reached.

Life cycle analysis diagram for a Sardinian system producing milk for cheese production

Figure 7. Source: Vagnoni et al. (2017)



Yaks in Golok, Amdo Tibet. Photo: Palden Tsering

Case 2: Amdo Tibet, China

Grasslands cover about 40% of the area of China, around 6%–8% of total global grasslands. Livestock production in these areas – of yaks, cattle, sheep and goats – is important for a large number of livelihoods, but also has a potentially significant impact on the environment. A LCA was conducted in Guinan in Amdo Tibet comparing an extensive pastoral village system with a more industrialised, intensive operation, involving feedlots, seeded pastures and imported feed (Zhuang *et al.* 2017).

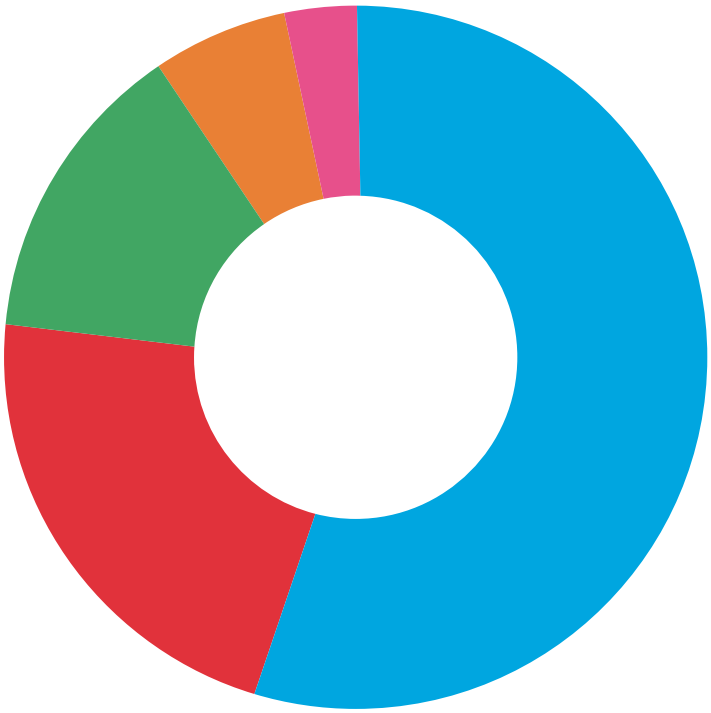
GHG emissions were higher in the more intensive operation, both in per area and per carcass weight terms. Importantly, this assessment included the effects of carbon sequestration of the different systems, as well as the production parameters. This made a significant difference, as carbon was not in balance (as is sometimes assumed). While the intensive system had a slightly lower production of methane, this was offset in the village system by lower costs of external inputs and higher levels of carbon sequestration. The reduction of methane emissions through intensification were significantly lower than is often suggested by the literature, at 6.95% rather than between 22% and 62%. This was because of the nature of the management of livestock, as well as because of the potential effect of cold temperatures in this region. Overall, the intensive system had 40% higher emissions per carcass weight (Figure 7).

A further study looked in more detail at the village system, contrasting a system under continuous grazing in fenced, individualised plots and a more traditional community-based system, involving movement across four seasonal pastures (Zhuang *et al.* 2019). On-farm emission patterns were broadly similar (around 9 kg CO_2-eq per kilogramme of meat), but when the carbon sequestration levels were added, the contrasts were striking. The flexible mobile system showed a net sequestration of carbon (of 0.62 kg CO_2-eq per kilogramme of meat), while the fixed, individualised system had a relatively high net emission level (of 10.51 kg CO_2-eq per kilogramme of meat).

Contrasts can be explained through differences in carbon sequestration, the predominance of perennials, incorporation of litter and the spreading and trampling in of manure, which resulted in lower emission estimates (Chen *et al.* 2015; Lu *et al.* 2015). Overall, light grazing contributes to soil carbon and nitrogen sequestration, while enclosed areas have compacted soil, less mineralisation, lower root biomass and reduced quality of leaf and grass litter (Shi *et al.* 2013; Zhou *et al.* 2017; Tang *et al.* 2018, 2019).

Contribution to emissions from a pastoral system in Amdo Tibet

Figure 8. Source: Zhuang et al. (2017)[a]



55%
Enteric CH_4

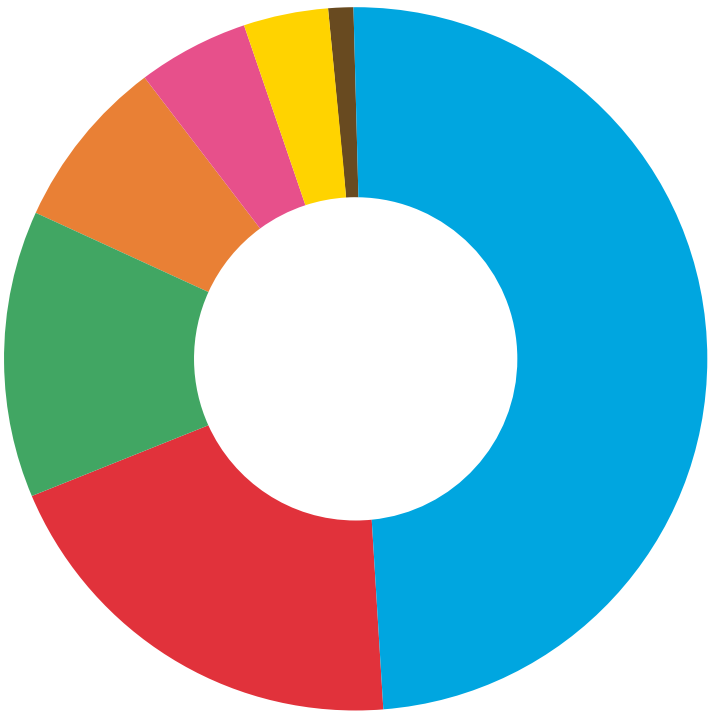
22%
Manure combustion GHGs

14%
Manure and urine N_20 (direct)

6%
Manure and urine N_2O (indirect)

3%
Pasture soil N_2O

Contribution to emissions from a combined extensive/intensive system in Amdo Tibet



49%
Enteric CH_4

20%
Manure combustion GHGs

13%
Manure and urine N_20 (direct)

8%
Diesel

5%
Manure and urine N_2O (indirect)

4%
Artificial grassland soil N_2O

1%
Pasture soil N_2O

Senegal dairy herd. Photo: Karen Marshall

Case 3: Northern Senegal, West Africa

A study in the Ferlo region of northern Senegal (mentioned above in section 4: Data biases) confirms the importance of looking at the wider system in the assessment of a pastoral system (Assouma *et al.* 2017, 2018, 2019). Here, the boundary was set at a 'landscape' level around a central borehole. The area included 354 pastoral settlements, 11,000 cattle and 1,800 small ruminants across an area of 706 km^2.

The study measured the overall carbon balance integrating animal emissions with the ecosystem as a whole. The annual carbon balance was found to be -0.04 +/- 0.01 t C-eq per hectare per year, with high levels of seasonal variation. During the wet season, the monthly balance was positive (+0.58 t C-eq per hectare), whereas the cold dry season saw a negative monthly balance (-0.57 t C-eq per hectare), and in the hot dry season the system was in balance (-0.05 per hectare). Overall for the study area, the methane and nitrous oxide emissions from animal manure and enteric fermentation (estimated at 0.71 t CO_2-eq per year) were mitigated by sequestration in the soil and vegetation (0.75 t CO_2-eq per year). This occurred particularly in the dry season, when livestock faeces, grass and leaves were incorporated into the soil, assisted by animal trampling and dung beetles.

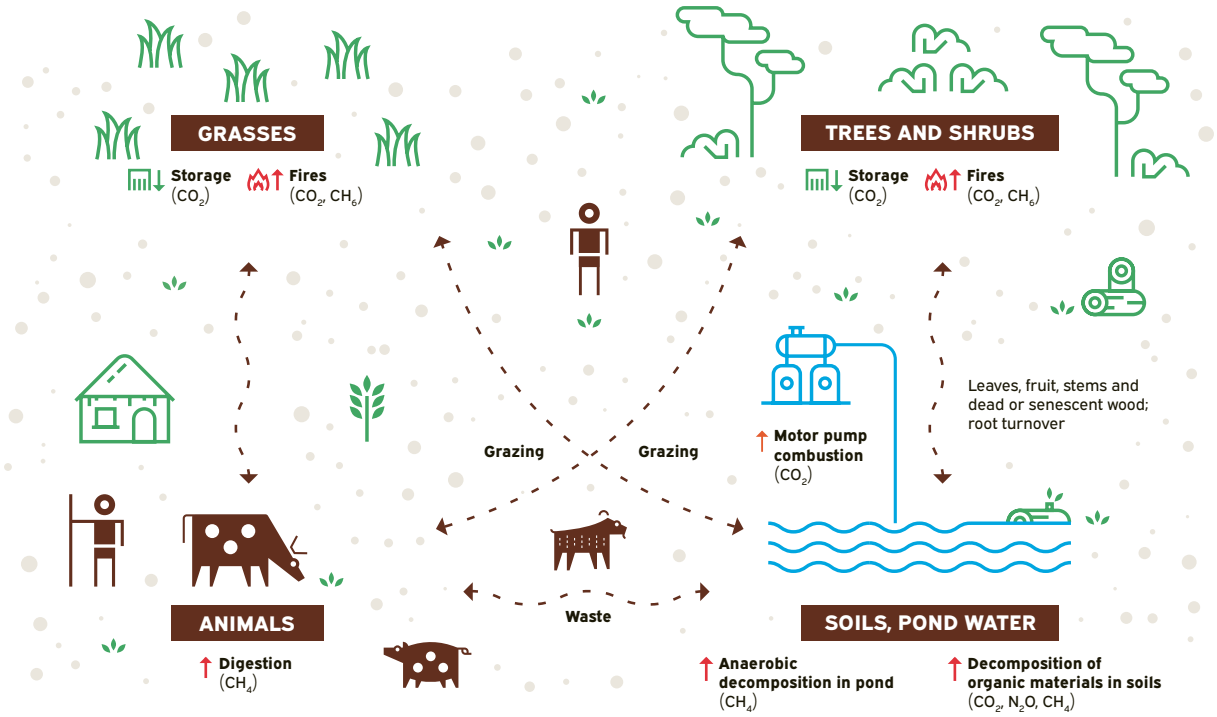
The studies show that the observed levels of feed intake of animals were far lower than standard estimates. The authors argue that current benchmarked estimates of enteric methane emissions may as a result be double actual levels. A system of light, mobile grazing meant that only around a third of primary grass production was consumed by animals, and the rest was returned to the soil. Sahelian grasslands are highly variable over time and space, requiring highly selective grazing through mobile herding. Feed intake is therefore of higher quality than the average grazing resource (Ayatunde *et al.* 1999, 2001).

There was also spatial variation in carbon emissions, with resting points near water sources having nearly 100 times the level of emissions than in open rangelands areas (cf. Butterbach-Bahl *et al.* 2020). This in turn offers potential for focused management of water points and animal waste use and disposal. Emission hotspots are places where wetter conditions near temporary ponds or in low-lying wetlands attract animals and thus the deposition of urine and faeces. Stagnant water increases methanogenesis and so GHG emissions under such conditions.

While the particular characteristics of the year of study (a drought year) makes extrapolation impossible, the importance of understanding seasonal and site-specific

A simplified systems diagram of GHG emissions and carbon storage in a pastoral ecosystem in Senegal

Figure 9. Source: Assouma et al. (2019b)



LEGEND

	Carbon sinks		Greenhouse gas emissions		Carbon from the atmosphere stored by plants		Recycling of carbon and nitrogen in plants and faeces

factors is highlighted. These qualify, sometimes radically, the standard default emissions factors often used in other studies. In understanding impacts in mobile systems, the bounding of the area of assessment becomes significant: the movement of animals out of the area due to drought clearly had an effect, and livestock-based emissions within the area would no doubt have increased if transhumance had been delayed.

Nevertheless, taking a broader systems approach differentiates land use across space and takes account of seasonal and inter-annual variations in use, offering in turn a much more sophisticated and realistic assessment. Figure 8 presents a schematic diagram of the key components and flows for such a systems analysis of livestock husbandry in a pastoral setting.

> **"A narrative that lumps all livestock together in one response is misguided and ineffective."**

These three case studies from pastoral areas from different continents reinforce a number of the points made in earlier sections:

1. Measuring on the ground

There is a need for field-based measurements to assess climate impacts, avoiding standard benchmarks that appear to be consistently biased against low-input extensive systems.

2. Wider benefits

There is a need to consider the effects of carbon sequestration in extensive rangeland based grazing systems, alongside the wider ecosystem benefits of pastoral systems.

3. Intervention points

There is a need to identify focused intervention points appropriate to the system to reduce emissions, such as focusing on particular sites in particular seasons, rather than generic recommendations to reduce emissions.

4. Impacts of grazing

There is a need to examine the consequences of relatively light, mobile grazing on carbon balances, as routes to both reduce emissions and increase sequestration of both carbon and nitrogen.

5. Systems approach

There is a need to adopt a wider systems approach, looking at processes beyond a farm to the wider landscape/ecosystem and value chain.

Livestock and climate change: *The need for a new approach*

Fulani boy in Niger herds his family's animals. Photo: ILRI / Stevie Mann

In order to determine the impact of the livestock sector on climate change, more empirical research is urgently required for complex, heterogeneous, extensive livestock systems, where data are currently lacking. It is insufficient to base policy recommendations on animal consumption and production based on default emissions and extrapolated estimates. A climate policy that misses its mark and damages livelihoods is one that is inappropriate and unjust.

In this report, we argue for a new conversation about the relationship between livestock and climate change. Correctly, the issue of livestock and the wider protein transition as part of a wider debate about food systems is rising up the agenda of climate mitigation policy (Lang 2009; Millstone and Lang 2003). There is little doubt that meeting the Paris Agreement targets will require major changes in land use and production systems globally. Currently, the debate focuses both on individual behaviour change (especially shifting diets to influence meat and milk consumption demand) and on wider changes in livestock production systems, with calls for reducing the area used by extensive livestock production through intensification and the development of meat and milk alternatives. This is turn is expected to result in the release of land for other uses, including tree-planting and 'rewilding'.

This increasingly mainstream narrative, which paints the production of livestock – and particularly red meat and milk – as a major focus for climate mitigation efforts, raises many questions, particularly for livestock systems in the Global South (Nagarajan 2021). Which livestock, and where? What diet changes, and for whom? Are tree-planting and land-saving alternatives realistic or effective? Does this apply to extensive and mobile pastoral production systems? Given growing demands for food production, can we afford the intensification of livestock production or crop agriculture on the land that is not spared, while rewilded or afforested areas will produce high methane emissions through continued herbivory and fire (Hempson *et al.* 2015; Archibald and Hempson 2016)? Will discourses of 'climate delay' (Lamb *et al.* 2020), promoting net-zero commitments through offsetting fossil fuel intensive activities in the Global North, result in displacement of extensive livestock producers by massive tree-planting investments in 'non-agricultural' grazing lands elsewhere? This report has highlighted many of these questions, probing the origins of the mainstream narrative and interrogating its assumptions.

The mainstream narrative is supported by many commercial and political interests and promoted by influential players, including campaign groups, sections of the media, businesses and prominent public figures.[38] This is often due to misunderstandings about the diverse nature of livestock production and a lack of data. The mainstream narrative is increasingly framing policy, particularly in the Global North. While shifts in diet and changes in industrialised livestock production systems in Europe, North America, eastern China, Australia and parts of South America are clearly needed, the narrative must urgently be nuanced lest it has detrimental consequences for less damaging extensive livestock systems that enhance livelihoods and environments across the world. Such systems often make use of marginal areas, supporting multiple livelihoods, diverse local economies and environmental sustainability, often in places where alternative land uses are impossible or would result in large-scale exclusion and injustice.

Extensive livestock systems exist in every continent except Antarctica and in nearly every country of the world, across more than half of the world's land surface. Directly supporting the livelihoods of many millions of people and the wider economic activities of many more, pastoralism – and other forms of extensive livestock production – should be a core part of any development strategy. As guardians of some of the most remote and environmentally vulnerable habitats globally, livestock keepers also have a major role to play in preserving, and indeed enhancing, biodiversity. They are at the forefront of the struggle against climate change, making use of skilled, adaptive practices to live with and from uncertainty in a volatile climate. Extensive livestock systems, including pastoralism, cannot be ignored in the climate debate, and organisations representing such producers need to be centre-stage in policy discussions.

The mainstream narrative, generated from aggregated data from a narrow set of cases, ignores the particularities of extensive livestock systems, frequently casting all

livestock and all meat and milk as bad. But, as this report has shown, this generalisation is often based on flawed assumptions and limited data. The application of the LCA methodology at the centre of most global assessments and policy proclamations needs to become much more nuanced, questioning standard assumptions. As we have seen, current policy recommendations emerging from these analyses focus on twin tracks of shifting consumption away from livestock products and changing production. These recommendations are frequently located in 'promissory narratives' of protein transitions addressing the climate change challenge and a politics of how alternative proteins are 'good', while meat, milk and livestock are 'bad' (Sexton 2018; Sexton *et al.* 2019). Going beyond such binary thinking is essential.

On the consumption side, managing demand through dietary and behavioural change is the key recommendation (Herrero *et al.* 2009; Willett *et al.* 2019), with a variety of 'ideal' diets being offered as alternatives to meat-rich and dairy-rich alternatives. The EAT–Lancet 'reference diet', for example, argues for a major shift to plant-based diets as well as to meat products such as chicken, resulting in a major backlash from some in the corporate meat industry lobby (García *et al.* 2019). Climate-damaging ways of life are concentrated among a 'consumption elite', often rich people in rich countries. There is a politics to nutrition policy that standardised dietary recommendations miss (Gillespie *et al.* 2013; Weis 2013; Walls *et al.* 2020).

Prosopis juli flora in the rangelands. Photo: Tahira Shariff

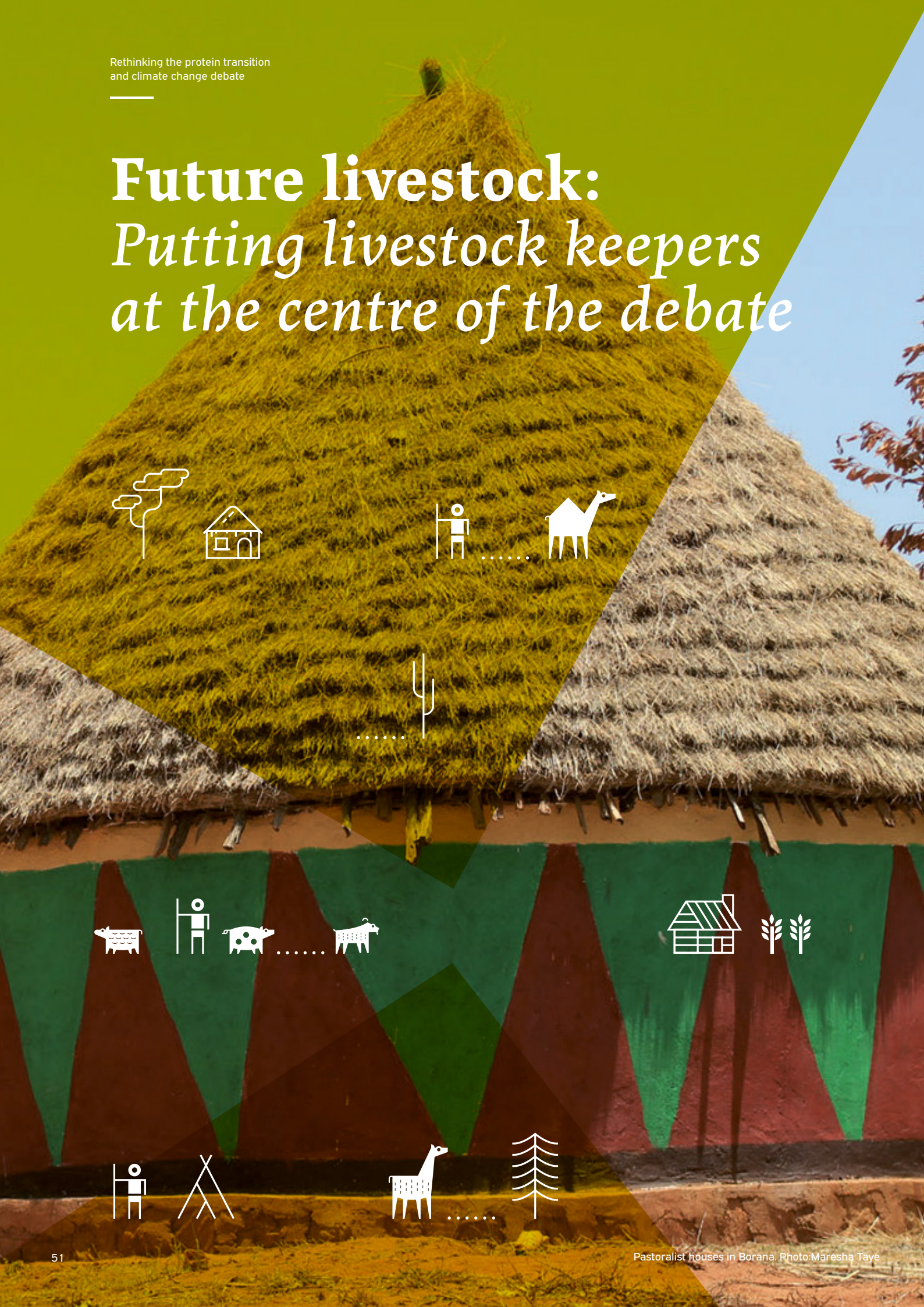
All this requires a more differentiated approach, recognising that many people in the world do not have enough meat or milk and that plant-based or cultured meat alternatives are not the solution. Many pastoralists with meat-intensive or milk-intensive diets, for example, do not have an alternative. Buying grains or vegetables depends on the terms of trade between livestock and other food products, which may not be favourable. The alternative of growing crops is not an option in many pastoral areas. Abandoning livestock production often means abandoning such areas, adding to wider socioeconomic problems. For pastoralists, maintaining nutrition through livestock products is essential and, despite their high intake of meat, milk and blood, their health status is often better than that of settled counterparts (Fratkin *et al.* 2004).

On the production side, the policy focus is on interventions based on improving efficiency through interventions in feed, breeding and animal husbandry (Herrero *et al.* 2009; Gerber *et al.* 2013b; Searchinger *et al.* 2019 Willett *et al.* 2019; Nordhagen *et al.* 2020). A popular intervention is to introduce higher-quality feed to grazing ruminants by implementing grazing rotations, fodder banks, improved pasture species and feed supplementation with crop by-products and feed additives (Adesogan *et al.* 2020; Herrero *et al.* 2020). The justification for this is that better animal diets result in lower methane emissions from enteric fermentation (Herrero *et al.* 2009; Ali *et al.* 2019), with tannin-rich feeds being potentially important (Hess *et al.* 2006; Aboagye *et al.* 2018). Other examples include improving animal health and reducing disease burdens, breeding more productive animals and investing in genetic improvement, including biotechnology to increase outputs from individual animals (ASAS 2019). All these 'efficiency'-focused interventions assume an intensification of animal production in a sedentary, increasingly industrialised system, and again ignore extensive livestock systems where such options are not possible and maybe not even advisable to achieve long-term climate targets. Instead, integrating LCA assessments with investigations of agricultural best practice for climate mitigation offers a route to improving policy while involving producers.[39]

These technical and policy responses emerge from the embedded assumptions in the modelling approaches used to assess the problem. The findings of assessments using LCA methodologies permeate the policy response. This results in generalised mitigation packages – whether around consumption or production – that ignore extensive livestock systems. The findings focus on contexts where diet change and intensification of production is feasible, essentially in rich, northern settings and industrialised, sedentary farms. This is not to say that all is well in extensive livestock production settings, as here too climate mitigation options are required linked to manure management, grazing patterns, water point location and mobility (Assouma *et al.* 2019a, 2019b). As Reid *et al.* (2004) argue, mitigation interventions in such systems will most likely succeed through building on existing, often traditional, knowledge and providing livestock keepers with food security and livelihoods benefits.

In sum, the mainstream narrative and associated policy and technical recommendations do not take account of extensive, seasonal, low-input systems – such as mobile pastoralism – and so ignore the livelihoods of significant numbers of poor and marginalised people across the world. In many places where these systems operate, alternatives are limited and diets and livelihoods are highly reliant on livestock production. Lumping such systems together with sedentary, industrialised, contained livestock production systems does not make any sense. Now is the time to differentiate, to improve the data availability and measurement approaches and to develop a more sophisticated and nuanced narrative that focuses appropriately on highly carbon-intensive forms of livestock production while celebrating and encouraging others that do much less damage, all while providing many other diverse social, cultural, economic and environmental benefits.

Future livestock:
Putting livestock keepers at the centre of the debate



Pastoralist houses in Borana. Photo:Maresha Taye

As the global demand for protein increases, there is no question that a transformation in the diets of the 'consumption elite' and the industrialised production systems (predominantly in the Global North) will be required to address climate change. However, such a shift must not undermine the livelihoods and economies of extensive livestock keepers across the world. The finger of blame should not be pointed in their direction as a result of simplistic, inappropriate assessment processes.

A more sophisticated alternative approach based on a more encompassing systems analysis will clearly point to areas where mitigation options exist, while also acknowledging the genuine benefits that extensive livestock systems provide to wider environmental services. A narrative that lumps all livestock together in one response is misguided and ineffective. Instead, we need to differentiate systems with higher and lower global warming impacts and better and more damaging meat and milk production. The low-input, extensive and mobile systems, including those managed by pastoralists, can potentially offer a low-carbon alternative that is environmentally beneficial.

Extensive livestock systems managed by millions of herders who are also skilled guardians of the land offer an alternative to a concentrated food system where meat and milk are produced through high-input, contained industrialised systems, reliant on carbon-costly feed, infrastructure and transport. Extensive livestock systems, and especially pastoralism, equally provide an alternative to the vision of a technology-driven, corporate-controlled low-carbon future based on alternative ways of producing proteins, through plant or fungus-based products or through engineered foods such as cultured meats. In fact, one part of the solution to climate challenges may have long existed as part of many livestock keepers' practice and environmental guardianship, connecting ecosystems and people, but without receiving the recognition and support it deserves.

We conclude by highlighting seven themes for action and six recommendations, along with a call to shift the debate, taking diverse livestock systems into account.

Data and methodology

The assumptions in the mainstream framing of the livestock/protein debate, rooted in generalised assessments through narrow applications of the LCA methodology, lead to extensive livestock being unfairly painted as one of the least sustainable and most climate-damaging land use practices and in need of radical transformation, if not elimination. However, the assumptions embedded in many LCAs' data lead to an overestimation of emissions from extensive livestock settings.

Increased rigour is required in the debate about the 'protein transition'. Emissions figures should not be taken at face value and should be interrogated, especially when estimates are extrapolated or are based on guesswork. Assumptions about baselines and alternatives also need to be evaluated for their realism and bias, and trade-offs between different pathways should be assessed, taking account of wider livelihood, social, cultural and environmental factors. Low-emission pathways may have differentiated effects by wealth, age and gender, for instance (Tavenner and Crane 2018; Kihoro *et al.* 2021). Rather than relying on narrow, expert-led, global LCA approaches that are undertaken at a distance from settings where policies impinge, more comprehensive, participatory systems analyses are needed (e.g. Crane *et al.* 2016) that are located in local understandings of complex, multi-functional livestock systems (Weiler *et al.* 2014).

In a systems approach, depending on the trade-offs between objectives, diverse metrics may be used, without a singular focus on 'efficiency' and per-animal/product impacts, but allowing (for example) a landscape based 'full-cost accounting' approach to inform judgements (Robertson and Grace 2004). Such discussions will result in a set of pathways for multi-functional livestock systems negotiated between climate mitigation, biodiversity protection, livelihood enhancement, dietary needs and other imperatives.

A more comprehensive, deliberative agri-food systems approach, rooted in an understanding of diverse pathways and their impacts, may help give a more realistic idea of the climate impact of complex, uncertain, heterogeneous, extensive landscapes. Such analyses need to be constructed by those with deep insights into different systems, with the

different pathways deliberated upon by those affected (Stirling *et al.* 2007). Rather than the false precision and rigour of limited assessments, a more bottom-up methodology is required (Holmes and Scoones 2000).

> **Rather than being destroyers of the environment and polluters of the planet, livestock keepers may act as important guardians of cultured, lived-in environments with long histories."**

Differentiating systems

An approach to policy that recognises the distinction between different systems of livestock production and between different commodities is essential. This will allow more effective targeting of priorities and solutions. A more differentiated analysis of the climate impacts and mitigation options suggests that global assessments and generic policy prescriptions are misleading and can be damaging. With a more sophisticated methodology for assessments supported by more granular data and context-specific analysis, we can move towards distinguishing between more and less carbon-emitting livestock management practices and production systems. This must go beyond the calls simply to intensify and increase feed quality to reduce methane emissions, making a realistic assessment of the options for mitigation in extensive – perhaps especially in mobile pastoral – livestock systems.

Patterns of emissions differ across production systems located in different parts of the world. Industrialised production supports the diet choices of a 'consumption elite' based in the rich Global North, whereas extensive, smallholder livestock keeping and pastoralism provide livelihoods for many and supply nutrient-rich foods for those diverse consumers. The generalised global narrative that dominates media and policy debates thus needs to be differentiated to take account of local environmental conditions, nutritional needs and livelihood priorities. Despite their rhetorical power in policy debates, simplistic prescriptions for global diet and food production will not work. Nuanced, context-specific solutions are needed that recognise diverse starting points and different pathways for transitions to low-emission alternatives.

Policy alternatives

Policy options have to become more sophisticated, allowing for diverse alternatives. Such alternatives may emerge from government regulations (restricting certain practices while encouraging others); price and cost incentives (adding taxes to some forms of production while allowing others tax breaks or even subsidies); or differentiating the market through standards and certification (linked to carbon, biodiversity or livelihood impacts). Consumer education on the value of sustainably produced livestock products needs to be combined with protection for low-input, extensive livestock production systems through recognising access to land, supporting patterns of mobility and so on.

Could we imagine, for example, meat or milk/cheese being sold from pastoral areas through a marketing standard that guarantees low climate impacts, improves biodiversity and enhances livelihoods for pastoralists? Setting standards, issuing certificates, designing regulations and defining tax levels and price points are notoriously difficult and prone to attempts to bypass or game the system, but they may also offer a basis for sending wider signals to the market. This would demonstrate a commitment by policymakers that this is a vital issue that needs addressing and that governments and businesses are serious about it, while recognising that a differentiated solution is required. With market and regulatory incentives operating to support particular practices, this may actually be a boon to extensive livestock production rather than a threat, as such livestock

keepers seek competitive advantages in a setting where supporting low-carbon options, while enhancing both biodiversity and livelihoods, is recognised.

We need to shift to an analysis that differentiates (relatively) good and bad production and consumption practices in relation to opportunity costs and alternatives in different places. It is not that all livestock production is bad for the climate, as we have seen. Indeed, not all meat-based and milk-based diets are bad either. The challenge of finding alternatives to carbon-intensive meat and milk production and over-consumption is undoubtedly important, but the alternatives may not necessarily be a simple choice between either plant-based and cultured meat diets, or the intensification of livestock and the release of land for tree-planting and regeneration. Simple choices are inappropriate for complex challenges. Instead, with a more nuanced understanding of different systems, particular intervention points around certain 'hotspots' can help mitigation responses become more sophisticated (e.g. Thomassen *et al.* 2008) .

Governance and control

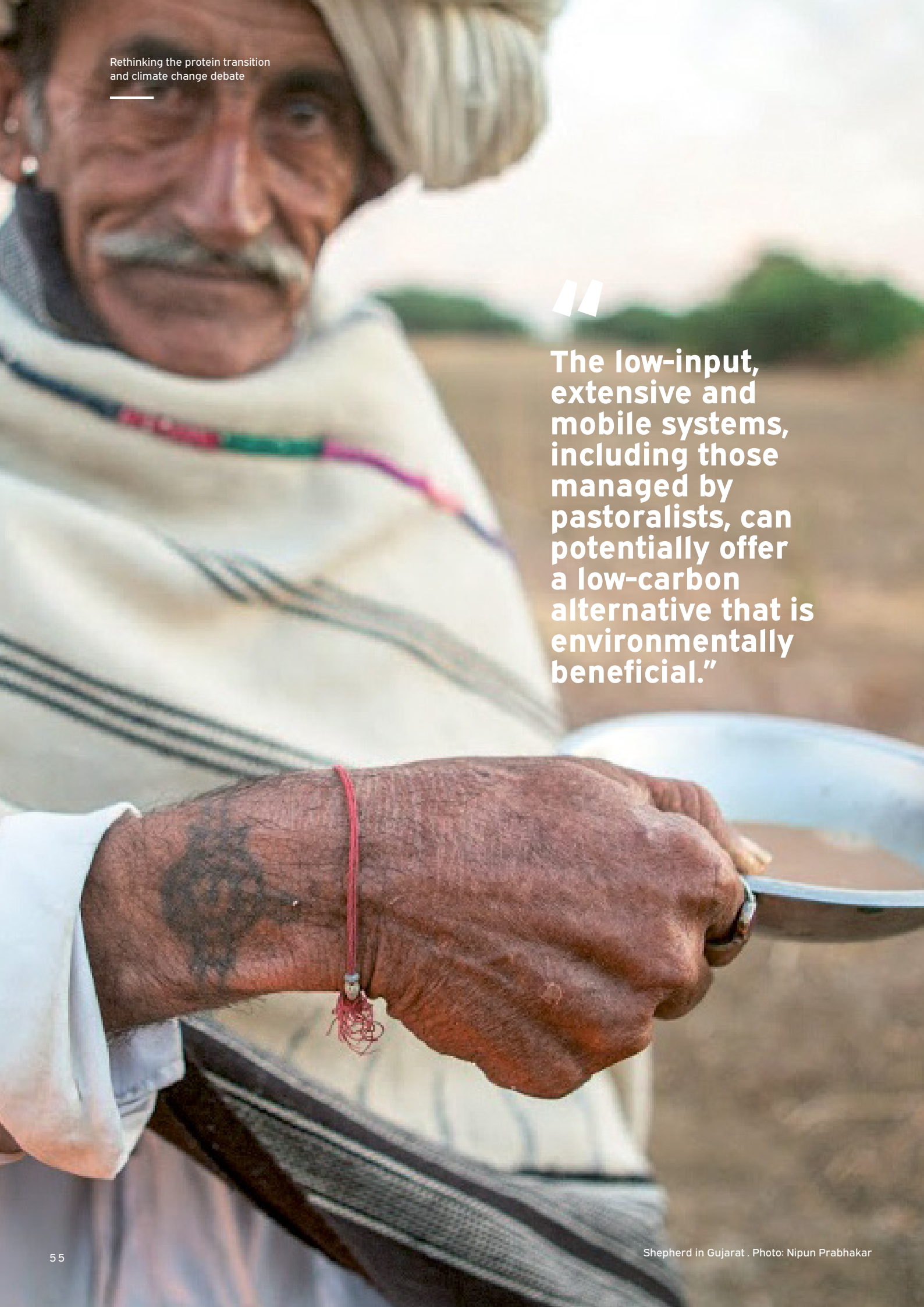
The current global debate is highly centralised and narrowly framed. The global assessments that define the debate are based on a limited set of expertise and present a global picture which can be both misleading and often captured by certain interests. The voices of pastoralists, for example, are nowhere to be heard. As a result, there is little deliberation around the trade-offs in agri-food systems in terms of who controls the system, and who benefits and loses from different alternatives. This makes initiatives such as the International Year of Rangelands and Pastoralists so important as focal points for mobilising alternative perspectives and ensuring the voices of pastoralists – and extensive livestock keepers more broadly – are heard in policy debates globally.[40]

Opening up such debates is vital. The seemingly benign narrative that an intensification of livestock production and a massive reduction in demand through diet change will release land for biodiversity conservation, tree-planting, ecosystem regeneration and rewilding hides questions around the control of resources and rights to livelihoods. In some settings, climate mitigation narratives are being used to justify processes of expropriation and enclosure, removing land for conservation uses on the basis that this is good for the climate, while excluding livestock keepers from landscapes that they have long managed through low-impact production systems.

Arguments that tree-planting or ecosystem regeneration without grazing will always result in greater carbon sequestration have been challenged, and too often tree-planting efforts result in the exclusion of other uses, becoming another form of plantation, paid for by governments or companies trying to meet their 'net-zero' commitments, often in far-distant places. The governance of carbon offsetting in particular is fraught with challenges, with powerful interests committed to certain styles of 'climate action' acting to exclude, yet using a climate mitigation narrative as an excuse.

In the same way, the imperative of a 'protein transition' is being used to justify large-scale conservation and rewilding efforts. These often exclude alternative livelihoods, including pastoralism, which with the right support may be significantly better for the climate, enhance biodiversity and improve livelihoods in poor and marginalised areas. Whose voices count in the debate about the protein transition? Currently, the debate is often shaped by large corporates and their venture capital backers, with vested interests in alternatives to meat and dairy products, alongside environmental organisations and campaigners with a deep commitment to climate change, biodiversity conversation and animal welfare, but little understanding of the complexities of livestock systems across the world. This is resulting in an unusual alliance being formed between emerging capitalist interests and environmental campaigns.

Opening up the debate about interests and positions in this discussion is important, as it exposes who is being silenced or ignored. It may surprise some progressive individuals and organisations that they are currently siding with capitalist investment interests against poor and marginal livestock keepers across the world. A more open discussion of the challenges of changing consumption and production in some parts of the world but not others, and supporting some alternatives not others in certain places, may help address questions of power and control in the governance of climate mitigation responses. Big profits are being made out of speculative promises linked to new products, such as cultured meat, yet, the real consequences of such shifts in food systems remain unknown, and the backing from some environmentalists may be misplaced.



"The low-input, extensive and mobile systems, including those managed by pastoralists, can potentially offer a low-carbon alternative that is environmentally beneficial."

Shepherd in Gujarat . Photo: Nipun Prabhakar

A full-cost assessment of alternatives and their impacts is required. For example, this must examine the carbon balance accounting of not only production, but also the full value chain and the consequences for wider land use change. Livestock are important for climate adaptation efforts, many of which can have mitigation co-benefits, and these options need to be included. Equally, the costs of enclosure and exclusion through the transfer of land to 'conservation' or 'carbon forestry' may be significant, as will be the loss of livelihoods from a blanket approach to policy. Support for alternative products, justified by their supposed climate benefits, may also have significant costs to economies and livelihoods of poorer livestock producers. All such wider effects need to be part of any full assessment. And so does a political assessment of the consequences of a narrowing control of the agri-food system through a corporatisation of the protein production market, compared to a more flexible system based on multiple ownership and control by diverse livestock producers. While climate mitigation is an imperative, solutions must emerge within wider societal priorities, requiring an assessment of the poverty-reducing impacts and justice consequences of any option.

A climate solution that concentrates power and privilege may in the longer-term not be the ideal. Only with such a wider evaluation of options and alternatives can a more realistic debate emerge. This will require a greater engagement with and inclusion of the voices of those whose livestock, land and livelihoods are currently being excluded.

Justice and livelihoods

Debates about the protein transition and the relationship between livestock production and climate change therefore raise questions of justice. Effective solutions to the climate change challenge must be just ones, involving 'just transitions'. Currently this is barely part of the debate.

Various dimensions of climate justice are raised. First, there are questions of epistemic justice, asking whose knowledge counts? In the dominant, expert-led assessment methodologies as currently applied, a particular focus on narrow quantification, efficiency and global aggregation helps construct a particular narrative. This acts to exclude certain data and the more disaggregated perspectives that other methodologies might highlight.

Second, there are questions of procedural justice and who is included and excluded in the debate. The process of deciding on mitigation options is currently highly constrained, centred around a particular set of technical solutions, and supported by a particular constellation of interests. Only some voices appear to count in the current debate, and this is reinforced by the approach to climate change and food systems discussions, situated in elite settings – such as the UN Framework Convention on Climate Change Conference of the Parties process or the UN Food Systems Summit – and framed around global problems and global solutions.

Third, there are questions of distributional justice, and of who benefits and who loses out. The emphasis on a global problem and solution, reinforced by particular methodologies and styles of policymaking, often acts to exclude a differentiated analysis, as we have seen.

Climate change is a global challenge requiring major structural changes in production and food systems. The contributors to climate change are distributed unevenly, meanwhile, solutions also have uneven effects. Only a more disaggregated approach can address questions of justice, ensuring that those who have been marginalised, including pastoralists, do not unnecessarily suffer from the consequences of climate mitigation pathways captured by particular commercial and political interests. A climate justice perspective must equally encompass rights to self-determination, autonomy, recognition and the pursuit of livelihoods in inhabited rangeland landscapes, based on resilient systems that generate valued outputs including environmental benefits.

Environmental guardianship and sustainability

Taking a broader systems perspective on livestock production and consumption brings into view the range of environmental impacts and benefits that particular types of livestock systems offer. Livestock are certainly GHG emitters but, just as are humans and other biological carbon-based creatures, they are also a key component of the wider agro-ecological system. They potentially offer a range of ecosystem services, as well as benefits to plant and animal biodiversity through particular types of grazing/browsing and animal breeding.[41] In addition, they may offer wider cultural and heritage benefits from certain management practices, embedded in particular

types of cultural and ethnic identity linked to particular landscapes and socioecologies.

Rather than being destroyers of the environment and polluters of the planet, livestock keepers may act as important guardians of cultured, lived-in environments with long histories. Certain grazing practices, as we have discussed, may result in greater levels of carbon sequestration, due to below-ground and soil effects, compared to tree-planting or rewilding approaches. Equally, a different type of high-value biodiversity may be generated through such grazing practices compared to the serried rows of forest plantations or even the scrub that emerges when livestock are removed from long-grazed ecosystems. Forests and assumed 'wild' environments may be less climate-friendly, or even less natural, than western imaginaries assume, while some extensive grazing settings – including those in agrosilvo-pastoral systems or linked with cropping – may offer much better alternatives, with people with deep environmental knowledges involved in the skilled management of peopled and cultured environments, collectively helping protect the planet.

A wider systems approach to thinking about alternative pathways to support climate mitigation must look at how all the inputs and outputs of production are managed, and what the opportunity costs of different land use options are. Developing mitigation options suitable for extensive, sometimes mobile, livestock production systems means avoiding a one-size-fits-all package of solutions. Instead, drawing on local understandings and practices, solutions that both reduce emissions and encourage carbon sequestration can be designed, with livestock keepers centrally involved. This may include adapted grazing and supplementary feed systems, the use of local browse species in feed to reduce methane production, the establishment of water points in ways that reduce methane emission hotspots, and the promotion of carbon sequestration through mobile light grazing and incorporation of organic matter.

Low-impact, extensive livestock systems can help avoid food and feed competition, with feed used that is unsuitable for human use and produced in places not appropriate for cropping. Reducing the use of livestock feed grown on arable land – for example, soy or alfalfa – means such systems can focus instead on extensive grazing on natural and semi-natural permanent grasslands, together with browsing and the use of crop residues and by-products as animal feed. Such systems facilitate a circular supply chain focused on reducing waste, with animal production playing an important role in a waste-free food system.

Food systems

Recasting the debate towards climate-friendly, sustainable food systems also turns the focus away from emissions from livestock in isolation, and onto the dangers of 'cheap food' (or protein) in the food system. Currently, this is driving massive increases in consumption and production of animal foods, with incentives geared towards producing more food at lower and lower costs, driving a particular type of 'efficiency'. Particular types of production (of both crops and livestock) are captured by the commercial interests of the drive to produce 'cheap things',[42] resulting in massive, devastating environmental damage.

What, then, is causing the climate and biodiversity crisis? It is not livestock production or meat/milk consumption per se, but the wider capitalist food system. It is this that needs to change – not through technical fixes, but through radical transformation of power relations and patterns of control. Here, low-impact, extensive livestock systems, including pastoralism, can show a way to the future. Summarising this report, we conclude with six recommendations, placing extensive livestock keepers, including pastoralists, at the centre of climate mitigation efforts.

Future livestock: six recommendations for meeting the climate challenge

1. Focus on the production process (industrial versus extensive pastoral production), not the product (meat and milk): Take a systems approach, incorporating both costs and benefits and realistic baselines. Avoid generalised global assessments that do not differentiate between systems of production. Instead, rely on evidence-based practices implemented locally within the varied diversity of agroecosystems rather than homogeneously across all systems.

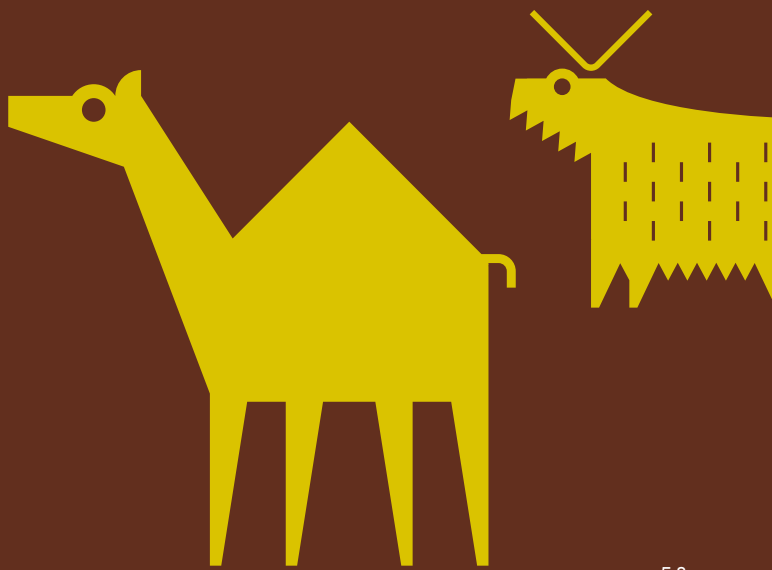
2. Avoid basing policy on simplistic, narrowly framed LCAs: Challenge the assumptions and improve data availability for global assessments, ensuring that analyses are appropriate to highly variable and often mobile extensive systems.

3. Support more research on carbon and nitrogen flows, context-specific emissions and carbon sequestration in extensive livestock systems, including in pastoral areas across the world: Such analyses must encompass differences across times and spaces, reflecting the complex dynamics of carbon and nitrogen cycles in such systems.

4. Develop practical solutions to mitigating GHGs together with livestock keepers, drawing on local knowledge and practices: This can focus both on feeding and manure management systems to reduce methane emissions and mobile grazing to encourage carbon sequestration.

5. Avoid generic recommendations on shifts in diets to address climate change: Focus instead on the rich, northern 'consumption elite', where the problem lies. Aim to level up access to high-quality nutrition addressing issues of distribution and equity, including high-density nutrients from meat and milk, especially for young children and undernourished populations.

6. Beware of elusive promises of quick-fix alternatives, whether of industrially produced meat or milk substitutes or alternative land uses that exclude livestock and people: Understand the political economy of such positions and the interests that they represent, and ask where alternative voices are in the debate. All this means bringing pastoralists and other low-input, extensive livestock producers – and the organisations that represent them – into global debates on climate change and the future of food systems.



Endnotes

1 www.50by40.org

2 www.weforum.org/projects/meat-the-future

3 www.fairr.org/sustainable-proteins/food-tech-spotlight/building-esg-into-the-alternative-protein-terrain/; www.riacanada.ca/magazine/building-esg-into-the-alternative-protein-terrain

4 www.un.org/en/food-systems-summit/action-tracks

5 See www.pastres.org for more details.

6 See e.g. Technology Review (2021) 'Bill Gates: Rich Nations Should Shift Entirely to Synthetic Beef', www.technologyreview.com/2021/02/14/1018296/bill-gates-climate-change-beef-trees-microsoft/; The Independent (2020) 'Go Vegetarian to Save Wildlife and the Planet, Sir David Attenborough Urges', www.independent.co.uk/climate-change/news/david-attenborough-vegetarian-vegan-meat-life-on-our-planet-netflix-wildlife-earth-a9689816.html; and www.mercyforanimals.org/blog/greta-thunberg-animals-environment

7 For example George Monbiot (2017) 'Goodbye – and Good Riddance – to Livestock Farming', www.theguardian.com/commentisfree/2017/oct/04/livestock-farming-artificial-meat-industry-animals; The Independent (2020) 'Going Vegan Is "Single Biggest Way" to Reduce Our Impact, Study Finds', www.independent.co.uk/life-style/health-and-families/veganism-environmental-impact-planet-reduced-plant-based-diet-humans-study-a8378631.html; Roger Harrabin (2019) 'Plant-Based Diet can Fight Climate Change – UN', www.bbc.com/news/science-environment-49238749, among many, many others.

8 See, 'Cars or Livestock: Which Contribute More to Climate Change?', September 2018, www.news.trust.org/item/20180918083629-d2wf0 and www.cgiar.org/news-events/news/fao-common-flawed-comparisons-greenhouse-gas-emissions-livestock-transport/. Arecent report from Friends of the Earth in Spain also offers a more nuanced perspective: www.tierra.org/wp-content/uploads/2020/09/Informe-Ganaderia-Cambio-climatico-Amigos-de-la-Tierra.pdf

9 While this narrative is now widespread, its direct impact on policies in livestock-dependent countries so far remains limited. However, dispelling myths and challenging assertions is important now before major shifts occur. To date, the impacts have been on changing markets (particularly in Europe) and the ways that national governments must report on national emissions levels through the UNFCCC reporting process, notably through the specification of Nationally Determined Contributions, and so how mitigation measures are planned and funded, often through donor efforts. In the UK, emerging plans for afforestation and removal of livestock from rangelands are central to carbon-neutral targets by 2030, while the European Union plans to plant three billion trees in the coming period as part of its climate mitigation policies. All these interventions will have a major negative impact on extensive livestock production systems and may not result in the desired climate mitigation outcomes.

10 Many more could be added, particularly around the now widespread debate about 'alternative proteins'; e.g. the World Economic Forum (www.weforum.org/whitepapers/meat-the-future-series-alternative-proteins) and RethinkX (www.rethinkx.com/food-and-agriculture), to name but a few. For example, RethinkX argue that "The current industrialised, animal-agriculture system will be replaced with a Food-as-Software model, where foods are engineered by scientists at a molecular level and uploaded to databases that can be access by food designers anywhere in the world. The will result in a far more distributed, localised, stable and resilience food-production system. … By 2035, about 60% of the land currently being used for livestock and feed production will be freed for other uses. … If all this freed land were dedicated for reforestation, all current sources of US greenhouse gas emissions could be fully offset by 2035" (Tubb and Seba 2019). In this assessment of narratives, however, we have focused on those focusing particularly on the link between livestock production and climate change.

11 The Paris Agreement: www.unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

12 See for example this press release: Greenpeace European Unit (2020) 'Animal Farming in EU Worse for Climate than All Cars', www.greenpeace.org/eu-unit/issues/nature-food/45051/animal-farming-in-eu-worse-for-climate-than-all-cars

13 There are many other more focused analyses using a similar methodology; for example, Stehfest *et al.* 2009; Tilman and Clark 2014; Hallström *et al.* 2015; Aleksandrowicz *et al.* 2016; Springmann *et al.* 2016a, 2016b; Clark and Tilman 2017; Clune *et al.* 2017.

14 www.ourworldindata.org/meat-production

15 The study, however, only looked at protein as a whole, not the nutrient value of products or available nutrient combinations. Animal protein of course has amino acid composition closer to human needs and a much higher nutrient availability than comparable amounts of plant protein (Drewnowski *et al.* 2015). Assessments of land use change also included simplistic assumptions of land use change. Other models show how livestock systems focused on resource conservation, reducing waste and with a circular supply chain can conserve land while not contributing significantly to climate change (van Zanten *et al.* 2018).

16 Notably those emerging from the FAO, including Steinfeld *et al.* 2006; Gerber *et al.* 2013a.

17 www.ox.ac.uk/news/2018-06-01-new-estimates-environmental-cost-food

18 www.theguardian.com/environment/2018/may/31/avoiding-meat-and-dairy-is-single-biggest-way-to-reduce-your-impact-on-earth

19 www.bbc.co.uk/food/articles/cut_food_emissions

20 See, Anne Mottet's and Henning Steinfeld's piece, 'Cars or Livestock: Which Contribute More to Climate Change?', September 2018, www.news.trust.org/item/20180918083629-d2wf0. See also, www.cgiar.org/news-events/news/fao-common-flawed-comparisons-greenhouse-gas-emissions-livestock-transport

21 The IPCC report states: "Improved livestock management is a collection of practices consisting of a) improved feed and dietary additives (e.g., bioactive compounds, fats), used to increase productivity and reduce emissions from enteric fermentation; b) breeding (e.g., breeds with higher productivity or reduced emissions from enteric fermentation), c) herd management, including decreasing neo-natal mortality, improving sanitary conditions, animal health and herd renewal, and diversifying animal species, d) emerging technologies (of which some are not legally authorised in several countries) such as propionate enhancers, nitrate and sulphate supplements, archaea inhibitors and archaeal vaccines, methanotrophs, acetogens, defaunation of the rumen, bacteriophages and probiotics, ionophores/antibiotics; and e) improved manure management, including manipulation of bedding and storage conditions, anaerobic digesters; biofilters, dietary change and additives, soil-applied and animal-fed nitrification inhibitors, urease inhibitors, fertiliser type, rate and timing, manipulation of manure application practices, and grazing management" (IPCC/Shukla *et al.* 2019: 570).

22 Although some conservationists advocate more inclusive, people-centred 'land-sharing' approaches as an alternative.

23 www.tabledebates.org/building-blocks/methane-and-sustainability-ruminant-livestock.

24 www.carbonbrief.org/guest-post-a-new-way-to-assess-global-warming-potential-of-short-lived-pollutants . The IPCC in the AR6 report of August 2021 now accepts the importance of using a number of different metrics, acknowledging the differences between them (https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf, section 7.6, boxes 7.3 and 1.6)

25 www.tabledebates.org/building-blocks/methane-and-sustainability-ruminant-livestock

26 www.ilri.org/outcomes/science-helps-tailor-livestock-related-climate-change-mitigation-strategies-africa

27 See Goopy *et al.* 2018, 2021; Zhu *et al.* 2018, 2020a, 2020b, 2021; Ndung'u *et al.* 2019; Ndao *et al.* 2020; Paul *et al.* 2020 for important work in Africa coming out of the International Livestock Research Institute.

28 www.fao.org/gleam/en/; see Gerber *et al.* (2013a), for example.

29 However, GLEAM does use GWP with carbon feedback, which gives different results to other assessments, where feedback effects are not included.

30 See www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/. This is a significant improvement on the 2006 guidelines, allowing for region-specific estimates, but most standard assessments still use estimates derived from earlier approaches and so continue to introduce biases.

31 Our World In Data (2020) Less Meat Is Nearly Always Better than Sustainable Meat, to Reduce Your Carbon Footprint. Oxford, ourworldindata.org/less-meat-or-sustainable-meat; Good Food Institute (2021) Plant-Based Meat, www.gfi.org/plant-based

32 See articles from the UK-based Sustainable Food Trust: www.sustainablefoodtrust.org/key-issues/sustainable-livestock/grazing-livestock

33 Sustainable Food Trust (2017) 'Grazed and Confused – An Initial Response from the Sustainable Food Trust', www.sustainablefoodtrust.org/articles/grazed-and-confused-an-initial-response-from-the-sustainable-food-trust

34 CO_2 fluxes from soils however are generally not accounted for in GHG inventories because they are assumed to be counterbalanced by CO_2 uptake through photosynthesis, although this is not the case when soil organic carbon is declining due to degradation.

35 See www.theguardian.com/environment/2021/may/11/lab-grown-meat-companies-swallow-record-investments, the World Economic Forum (www.weforum.org/projects/meat-the-future), and RethinkX (www.rethinkx.com/food-and-agriculture) for high-profile, promotional initiatives.

36 See also ILRI (2020) 'A Call for a Holistic View of Meat Eating by Lawrence Haddad, of the Global Alliance for Improved Nutrition (GAIN)', www.ilri.org/news/call-holistic-view-meat-eating-lawrence-haddad-global-alliance-improved-nutrition

37 For an accessible overview, see www.youtube.com/watch?v=NbO4EEaH7YM

38 Alongside the advocacy of industrialised cultured meat mentioned earlier, global corporate interests are backing major tree-planting offsetting schemes as part of their efforts to 'green' business and address climate change. The commitment to plant one trillion trees for example is part of the World Economic Forum's efforts to promote 'nature-based solutions': see www.1t.org

39 See the work of www.sheeptoship.eu for examples of such approaches.

40 See www.iyrp.info

41 See FFCC 2021 and www.pastres.org/2021/05/14/crossbreeding-or-not-crossbreeding-that-is-not-the-question

42 See Patel 2012; Weis 2013; and Patel and Moore 2017 for a wider discussion.

a Reprinted from Journal of Cleaner Production, vol 147, Zhuang M., Gongbuzeren, Li W., Greenhouse gas emission of pastoralism is lower than combined extensive/intensive livestock husbandry: A case study on the Qinghai-Tibet Plateau of China, figure 2, Copyright (2017), with permission from Elsevier.

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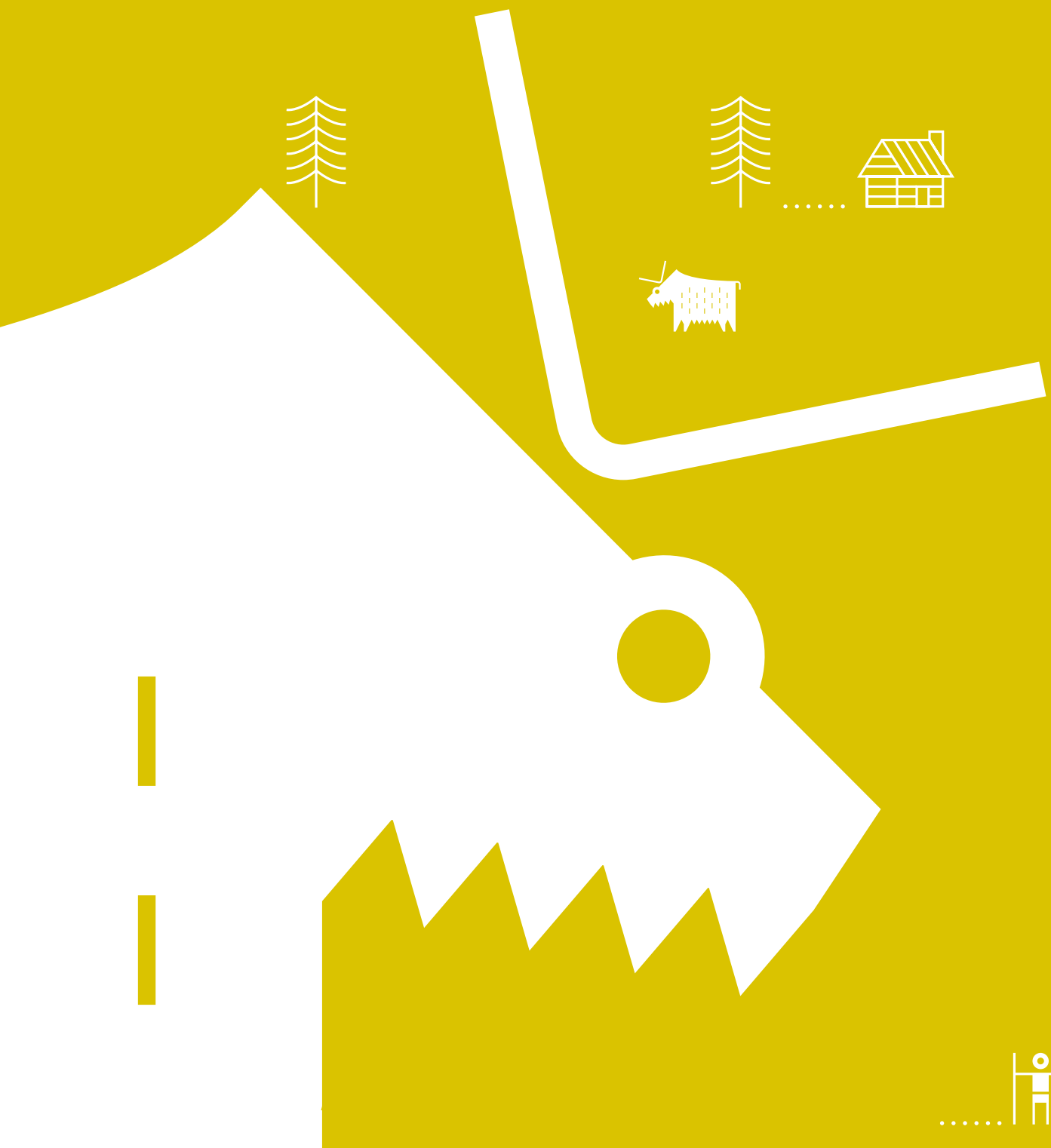

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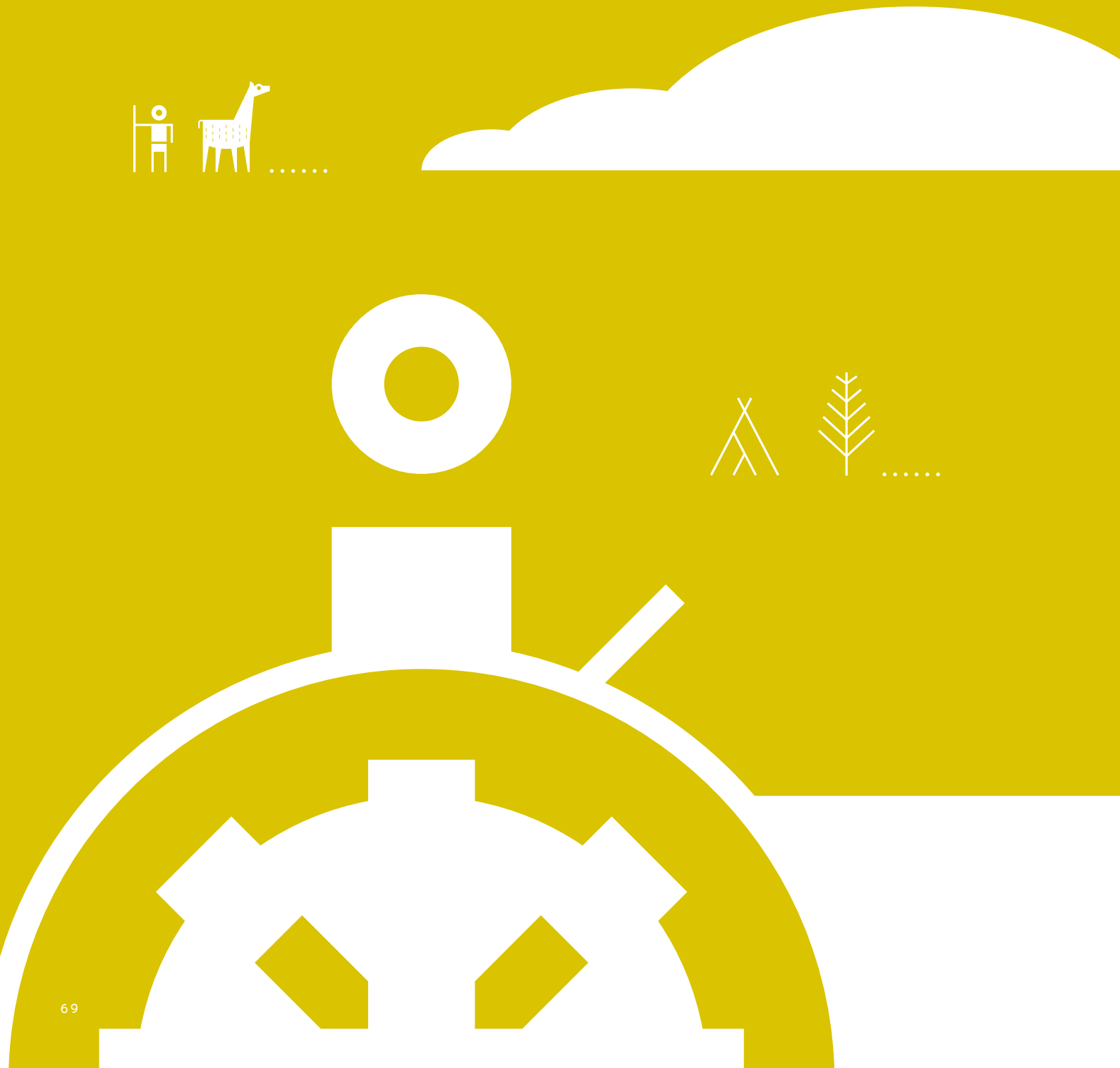
Appendix 1

Collaborating organisations



PASTRES
Pastoralism, Uncertainty, Resilience

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The Alliance for Mediterranean Nature and Culture (AMNC)

The Alliance for Mediterranean Nature & Culture (AMNC) is a group of NGOs working together to build awareness and knowledge of cultural landscapes, advocate for the traditional practices that maintain them and sustain the benefits they provide for biodiversity and local livelihoods.

www.mednatureculture.org

The Centre for Sustainable Development and Environment

The Centre for Sustainable Development and Environment (CENESTA) is a not-for-profit civil society organisation based in Tehran, Iran. CENESTA struggles to re-empower indigenous peoples and local communities in Iran and beyond, including indigenous nomadic tribes, forest people and coastal and marine areas communities. CENESTA is a member of UNINOMAD (Union of Indigenous Nomadic Tribes of Iran).

www.cenesta.org/en

Coalition of European Lobbies for Eastern African Pastoralism

CELEP is an informal advocacy group of European organisations and specialists partnering with pastoralist organisations and specialists in Eastern Africa who combine forces to lobby their national governments and European and Eastern African bodies to explicitly recognise and support pastoralism and pastoralists in the drylands of Eastern Africa.

www.celep.info

European Shepherds Network

The ESN brings together extensive livestock farmers and shepherd organisations in Europe that share common goals such as supporting pastoralism and building a cohesive social movement. It is also the regional chapter of the World Alliance of Mobile Indigenous Peoples and Pastoralists (WAMIP).

www.shepherdnet.eu

International Institute for Environment and Development

The IIED is an independent research organisation that aims to deliver positive change on a global scale.

www.iied.org

International Livestock Research Institute

The International Livestock Research Institute (ILRI) works for better lives through livestock in developing countries. ILRI's mission is to improve food and nutritional security and to reduce poverty in developing countries through research for efficient, safe and sustainable use of livestock—ensuring better lives through livestock.

www.ilri.org

ILC Rangelands Initiative

The ILC Rangelands Initiative is a global network and programme working to make rangelands more secure for local rangelands users.

www.rangelandsinitiative.org

Italian Network on Pastoralism

The Italian Network on Pastoralism (APPIA) is a non-profit organization registered in 2017 by a heterogeneous group of breeders, researchers, veterinarians, and other operators in the livestock sector, particularly concerned with extensive breeding, pastoralism – and its social, cultural and political implications.

The APPIA Network seeks to improve the visibility of pastoralism among citizens, consumers as well as decision-maker, advocating for the capacities, needs and interest of pastoralists to be taken into account at different levels, including in discussions on agricultural policies.

www.retepastorizia.it

League for Pastoral Peoples and Endogenous Livestock Development

LPP is a research and advocacy organisation for pastoralists and small-scale livestock keepers.

www.pastoralpeoples.org

Spanish Platform for Extensive Livestock Systems and Pastoralism

The Spanish Platform for Extensive Livestock Systems and Pastoralism is a network of over 200 people and organisations committed to supporting this farming activity.

Through biannual meetings and online communication tools, the platform enables livestock farmers, conservationists, researchers, government officers, farm advisors and many other third-sector actors and stakeholders to exchange information and collaborate more closely.

www.ganaderiaextensiva.org

Vétérinaires Sans Frontières International

VSF International is a network of non-profit organisations working all over the world to support small-scale farmers and livestock keepers. With our projects and programmes we serve the most vulnerable rural populations and act collectively to advocate in favour of small-scale family farming and livestock keeping, pastoralism, animal and human health, and a healthy environment.

www.vsf-international.org

World Alliance of Mobile Indigenous Pastoralists

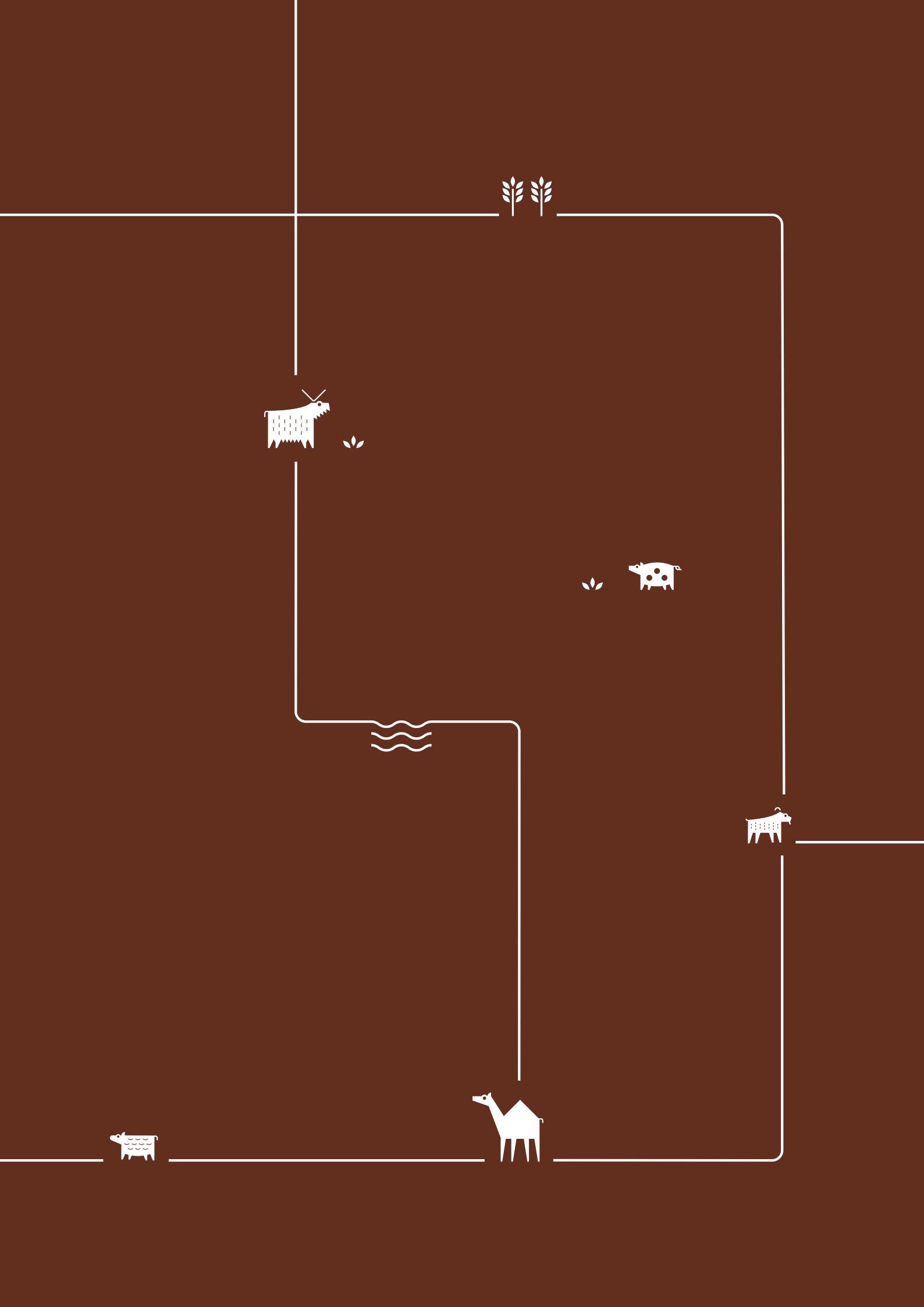
WAMIP is the alliance of pastoralist communities and mobile indigenous peoples throughout the world, and our common space to preserve our forms of life, in pursuit of our livelihoods and cultural identity, to sustainably manage their common property resources and to obtain full respect of our rights. As an independent grassroots movement we work together with other civil society organisations to influence policymakers at national, regional and international level, and supranational bodies as the UN and subsidiary organisations like FAO, CBD and others.

www.wamipglobal.com

Yolda Initiative

Yolda Initiative is a nature conservation organisation operating at international level and works for the conservation of biodiversity through research, advocacy, communications and collaborations.

www.yolda.org.tr



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