Does better circularity in livestock require a paradigm shift?

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Credit: WUR website Circular agrofood system

Circularity can limit negative impacts on natural resources and enhance positive ones

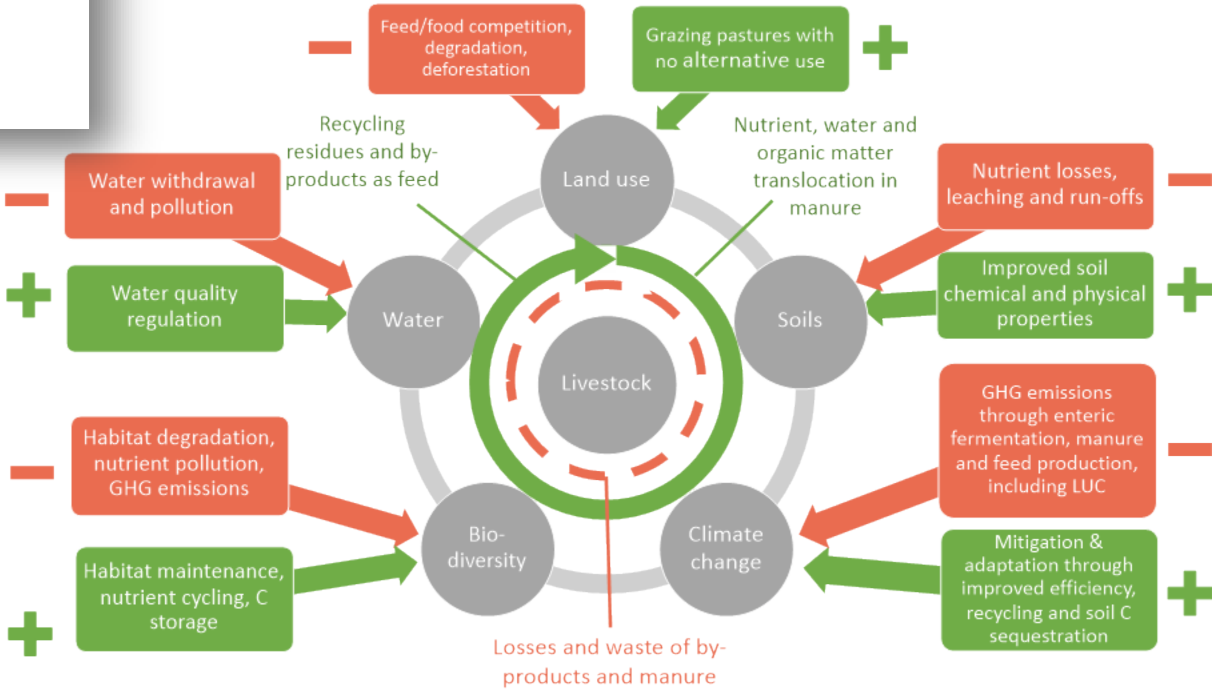
JN THE JOURNAL OF NUTRITION
journal homepage: www.journals.elsevier.com/the-journal-of-nutrition

Critical Review

Friend or Foe? The Role of Animal-Source Foods in Healthy and Environmentally Sustainable Diets

Ty Beal[1,2,*], Christopher D. Gardner[3], Mario Herrero[4], Lora L. Iannotti[5], Lutz Merbold[6], Stella Nordhagen[7], Anne Mottet[8]

https://doi.org/10.1016/j.tjnut.2022.10.016



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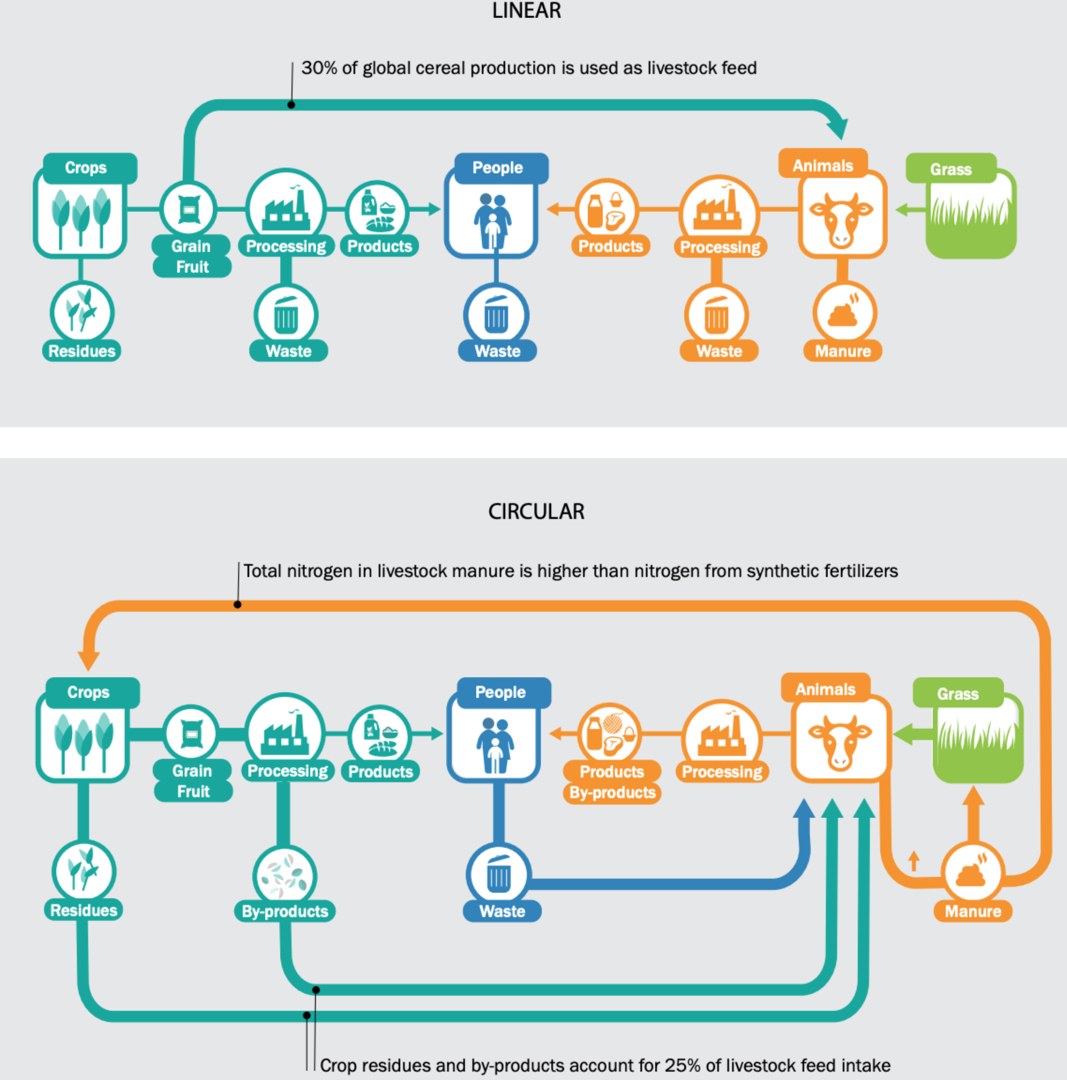
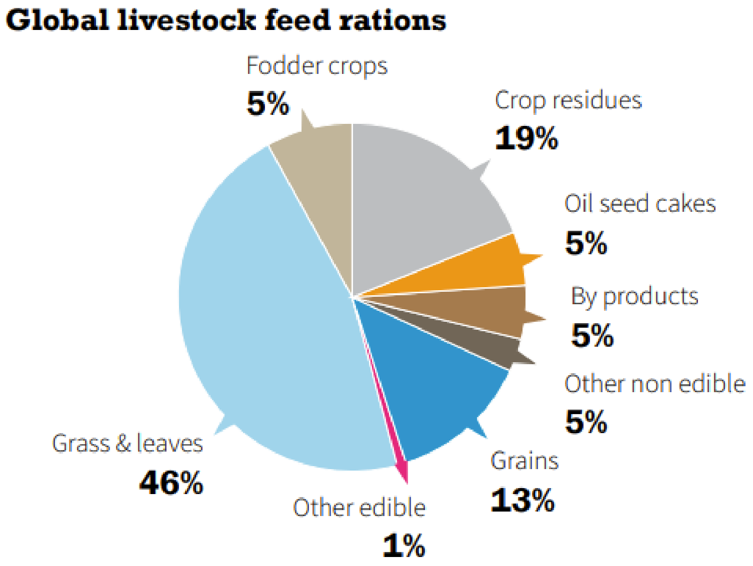
Circularity of what?

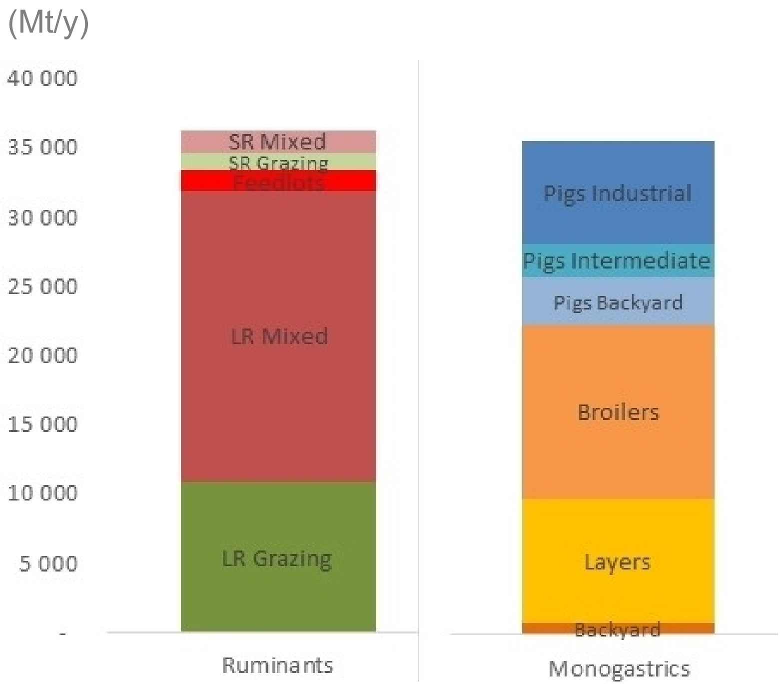
- Humans harvest ~25% of total biomass produced on Earth each year
- Annual feed intake of livestock = 20% of global human appropriation of biomass, or ~6 billion tons of DM/year
- Manure could cover >80% of N and P requirements but supplies only ~12% of the gross N input for cropping
- Consuming more by-products from ASF processing can also reduce waste (10-15% of liveweight)



Total feed intake and protein production of livestock systems



Source: Mottet *et al.* (2017). In: *Global Food Security*



Feed use efficiency: ruminants vs monogastrics

	FCR 1	FCR 2	Meat FCR 2	FCR 3	Protein FCR 2
	Kg DM /kg protein	Kg edible DM /kg protein	Kg edible DM /kg meat	Kg compete DM /kg protein	Kg edible protein /kg protein
Ruminants	133	6	2.8	6.7	**0.6**
Monogastrics	30	16	3.2	20.3	2.0
All	80	12	3.1	13.7	1.3

Source: Mottet et al. (2017) Global Food Security

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Feed use efficiency: industrial vs low-input

			FCR1	FCR2	FCR2 meat	FCR3	Protein FCR1	Protein FCR 2	Protein FCR3
			Kg DM feed/ kg protein product[1]	Kg DM human edible[2] feed/ kg protein product[1]	Kg DM human-edible[2] feed/kg meat[3]	Kg DM human-edible +soybean cakes[4]/kg protein product[1]	Kg protein feed// kg protein product[1]	Kg protein from human-edible feed[2]/kg protein product[1]	Kg protein from human-edible +soybean cakes[4]/kg protein product[1]
Non OECD	Cattle & buffaloes	Grazing	195	1.6	0.9	1.9	20	0.2	**0.3**
		Mixed	171	4.8	3.1	5.6	16	0.5	1
		Feedlots	99	37.1	7.9	39.6	16	3.5	**4.8**
OECD	Poultry	Backyard	59	0	0	**1**	10	0.5	0.5
		Layers	18	13.8	0	**15.7**	3	2.9	2.9
		Broilers	26	18.8	3.6	**24**	6	5.1	5
	Pigs	Backyard	57	0	0	1.4	7	0.6	0.7
		Intermediate	35	21.1	4.3	25.1	6	4.5	4.5
		Industrial	29	20	4	24.1	6	4.4	4.4

Source: Mottet et al. (2017) Global Food Security

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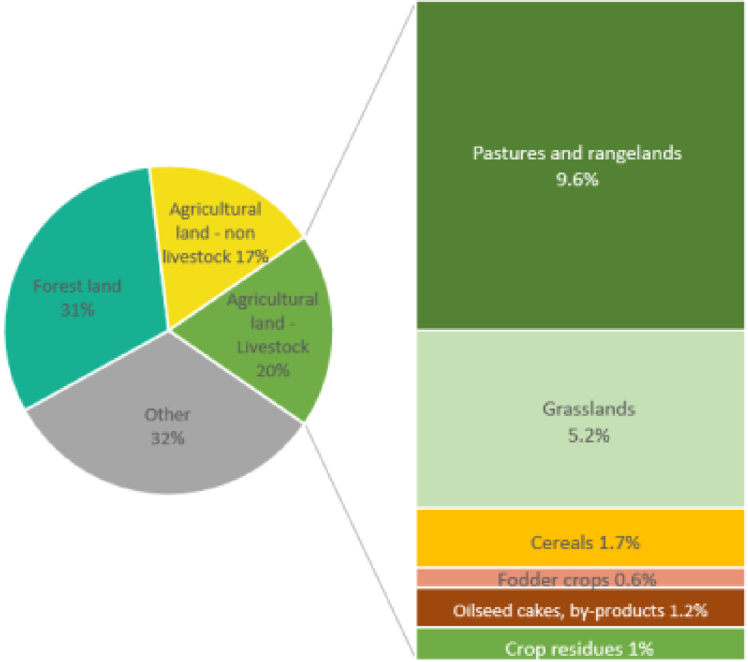
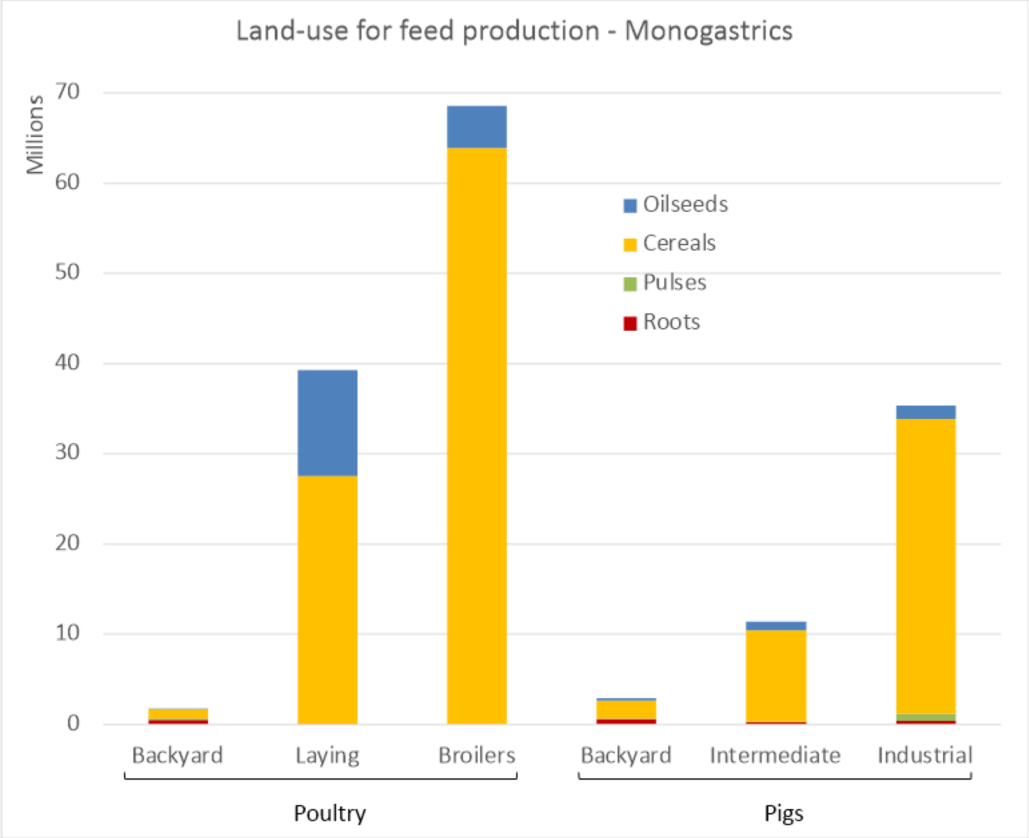
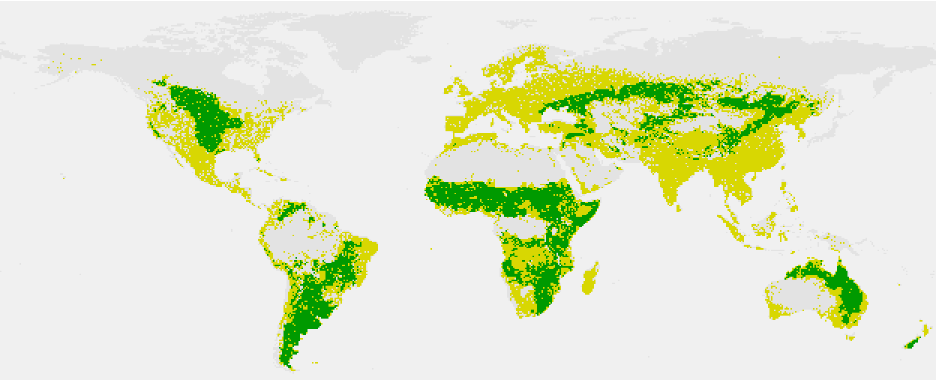
Land use: grazing ruminants use grasslands and industrial monogastrics use arable land





Source: Mottet et al. (2017) Global Food Security

Different solutions in different biomes



In grassland biomes, how to manage livestock for healthy grassland ecosystems?

- Synergies between productivity, biodiversity conservation, land restoration, and carbon sequestration
- Multi-level biodiversity conservation: local breeds (and resilience), wild species, ecosystem services

In other biomes, how to minimize the footprint of livestock?

- Sustainable sourcing and production of feed crops (avoiding deforestation)
- Landscape integration: crop-livestock, silvopastoral, with aquaculture…
- Circularity, optimizing use of biomass and mitigating pollution
- Productivity, (natural resource use) efficiency and sparing land for nature

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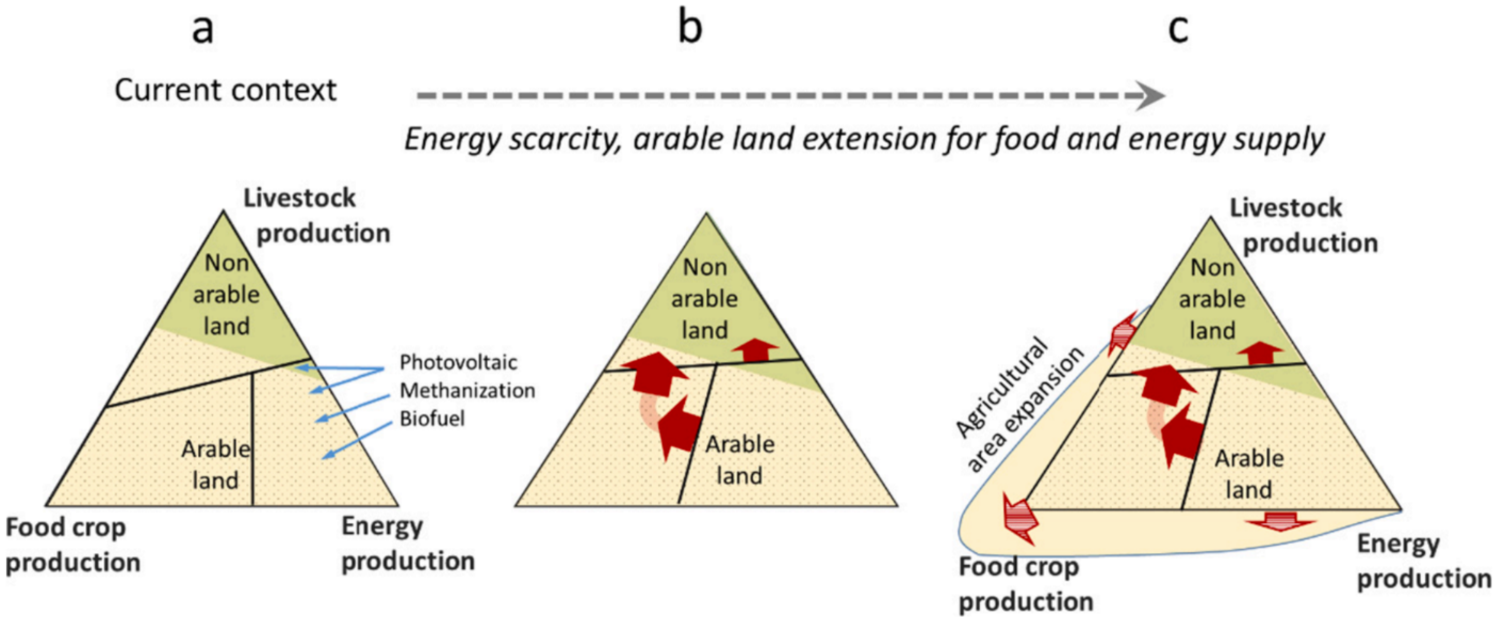
Food-feed-energy nexus and consequences for economic sustainability of livestock

- Energy is a production factor in most systems
- Agricultural land is also used to produce energy:
  - Biofuels from corn, rape seed, sugar beet etc.
  - Biomass collection for anaerobic digestion
  - Photovoltaic panels
  - Wood

→ Scarcity and increasing cost of energy along with competition for the use of land will lead to a lower profitability and competitiveness of livestock that depend on feed (or "Arable Land Based" livestock. Up to 74% of global livestock protein production)

Benoit & Mottet, 2023. Agricultural Systems

Energy scarcity and future consequences for land use



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Low energy efficiency in livestock

- From representative data in France
- Efficiency of using non-renewable energy 6 to 12 times lower for animal production systems than for crop production systems → 6 to 12 times more affected by changes in energy prices
- Low competitivity due to low feed efficiency of animals (maintenance requirements) and to production systems, particularly type of feed (nutrient-dense feeds vs fodder)
- 75% of energy used in cattle production is through animal feeding (LCA, including purchased feed, fertilizers etc.)

	Energy efficiency (ratio between the gross energy in the product and the energy used)
Beef	0.44
Dairy milk	0.59
Pork	0.86
Crops (cereals, pulses)	5.4

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Moving away from the use of cultivated feed resources

- crop residues, cover crops and coproducts from food processing, waste.

E.g. Nearly 25% of net primary production of French agriculture is non-used biomass (byproducts + non-grazed grasslands in cropping systems)

- Forages from areas unfit for mechanization, with heterogeneous feed values in time and space, that can only be harvested by grazing (lower cost of forage harvesting, storing, distribution, manure spreading).

E.g. energy used -50% with high cellulose fodder dispersed in space (rangelands or vineyards) in sheep production in France (Benoit et al., 2019)

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Redistributing livestock in territories

- Avoid competition with arable land AND with resources that have a “harvestable” energy content, for example for biogas production
- Give priority to resources with low spatial concentration, for which mechanical harvesting is restrictive and costly: heterogeneous and spatially diluted crop residues, vineyards and orchards, mechanized but not very productive pastures
- Leading animals to the resource, by practicing transhumance, seasonal or not, and using mountains, lowland, vineyards, orchards or forests, reduces energy consumption but also GHG emissions per kg of product (Vigan et al., 2017; Ocak Yetişgin et al., 2022).

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What type of animal performance is needed?

- Feed efficiency takes little account of low-nutrient and highly cellulosic resources, or "low opportunity cost feed" not edible for humans.
- We argue that we need to clarify the notion of feed efficiency to design desirable feeding strategies. We propose the notion "qualitative efficiency" which should take precedence over the notion of quantitative efficiency

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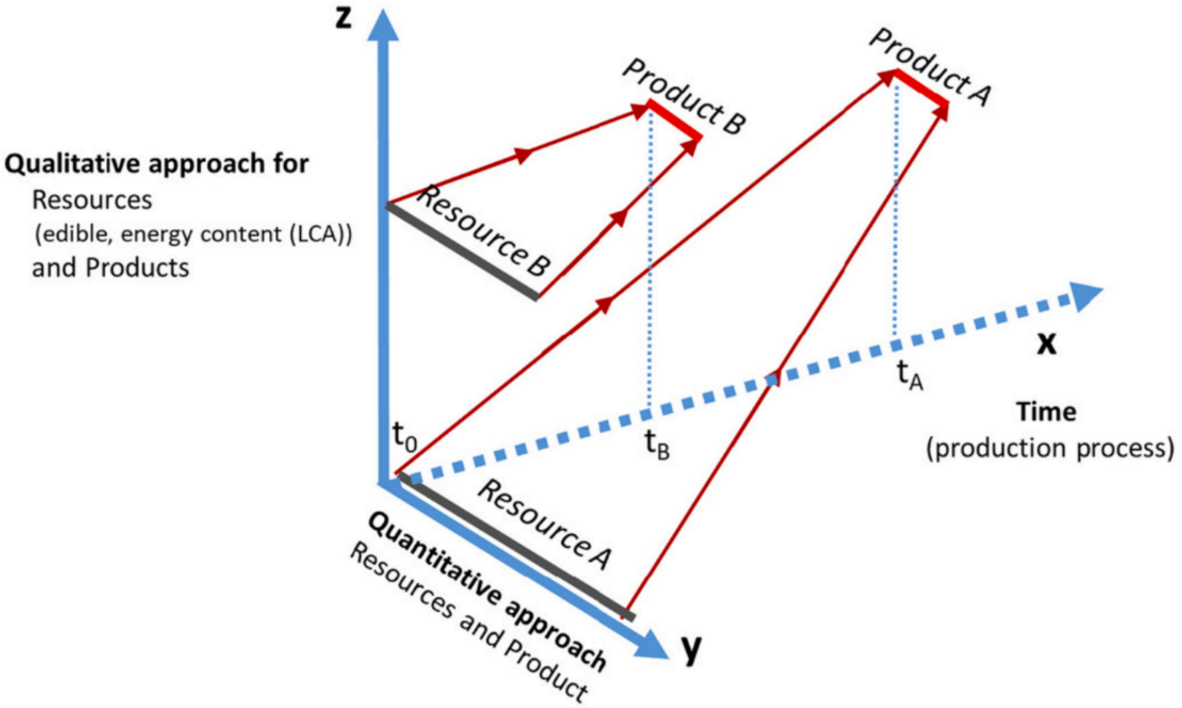
What type of animal performance is needed?

Use a wide range of resources, heterogeneous in time and space, with strong mobility skills and sufficient hardiness to withstand terrain and climatic conditions.
→ selection is particularly important (Ducos, et al., 2021)



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What role for livestock?

- Animal = “collector/concentrator of energy and proteins”, with maximum autonomy and reduced production costs
- Reducing breeding and feeding costs in the new energy context and to reduce competition for land
- Recognizing other services provided by livestock (Dumont et al., 2019) and their adequate remuneration, including cultural landscapes

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What policies for livestock?

- Reshape national breeding policies (and animal feed policies when exist)
- Balance public support for renewable energy (e.g. biofuels, biogas) that can increase competition for land
- Develop regulations and certifications to increase the use of byproducts and food waste as animal feed
- Support efficiency gains in livestock systems that do not currently depend on feed, such as pastoral or grazing and mixed systems in low-income countries (animal health, herd management etc.)

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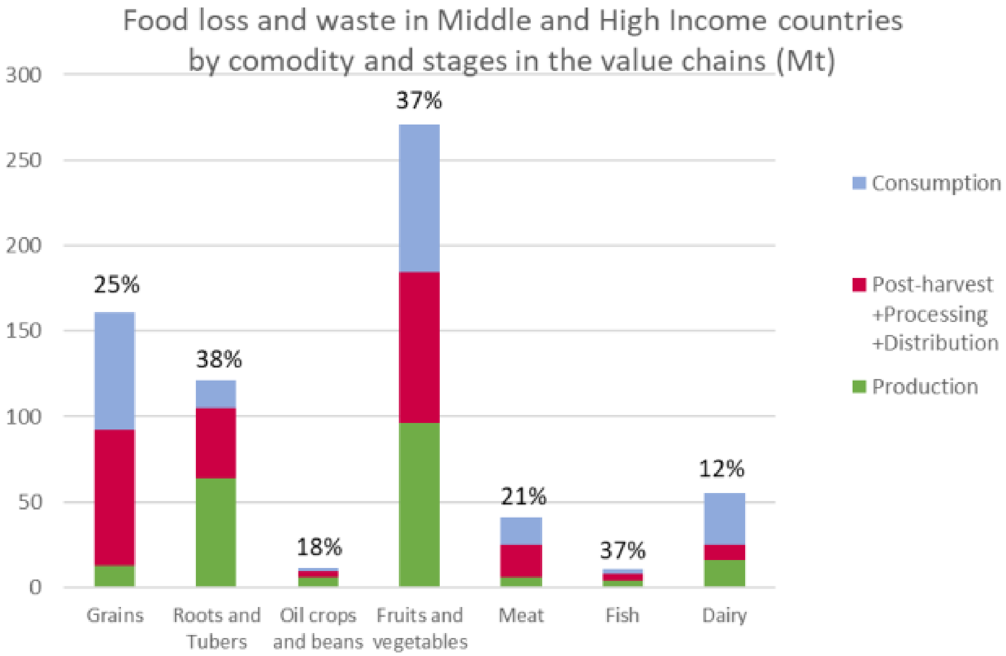
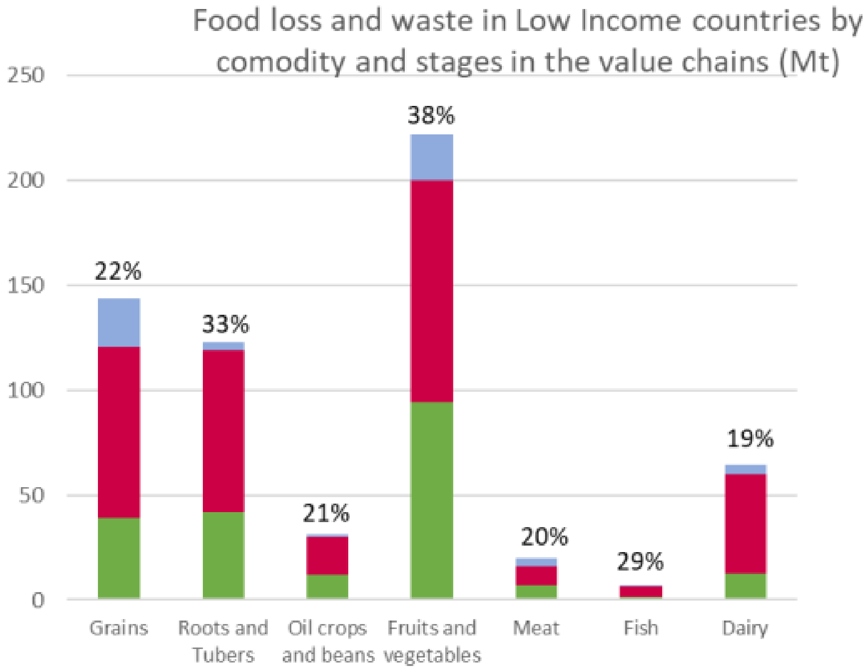
Food loss and waste are higher at production stage in low-input systems in LMIC. What can we do to reduce them?





Adapted from Spang et al., 2019. Annual Review of Environment and Resources.

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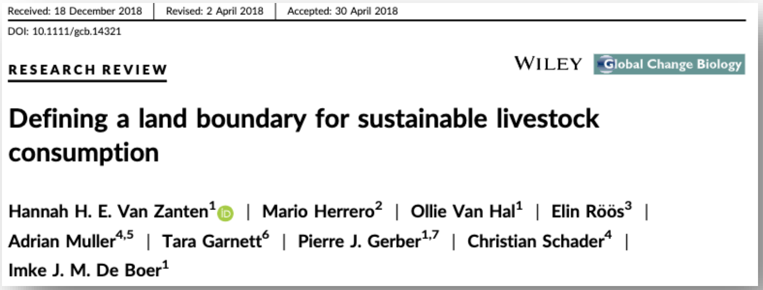
Circular livestock systems have the potential to provide a significant share of daily protein requirements (50-60g)


Received: 18 December 2018 | Revised: 2 April 2018 | Accepted: 30 April 2018
DOI: 10.1111/gcb.14321

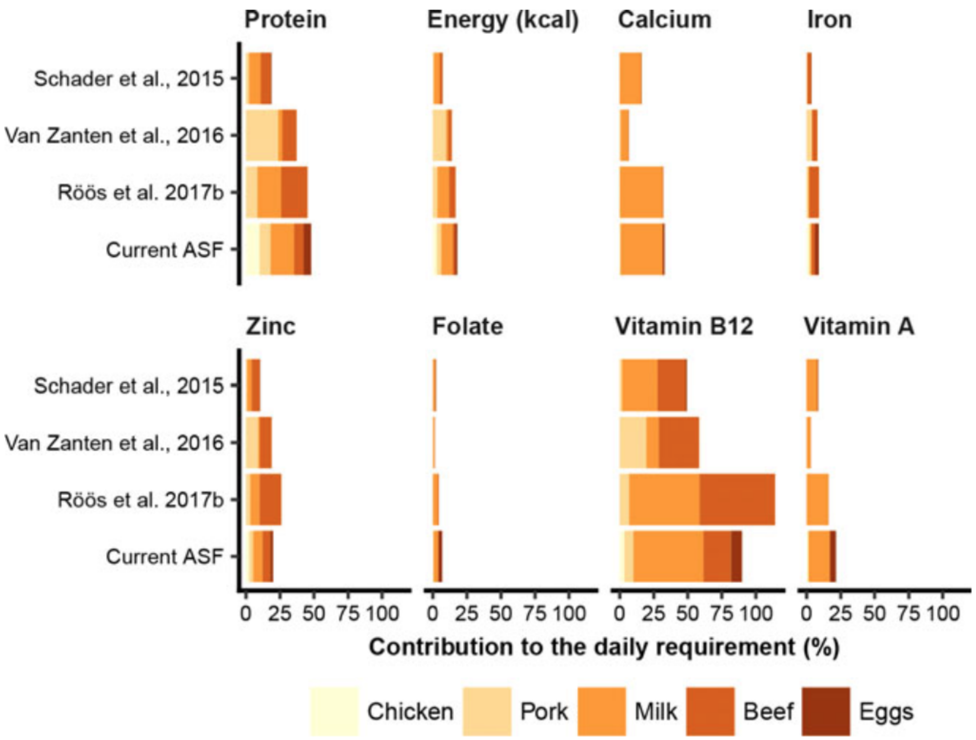
RESEARCH REVIEW

WILEY Global Change Biology

Defining a land boundary for sustainable livestock consumption

Hannah H. E. Van Zanten[1] | Mario Herrero[2] | Ollie Van Hal[1] | Elin Röös[3] | Adrian Muller[4,5] | Tara Garnett[6] | Pierre J. Gerber[1,7] | Christian Schader[4] | Imke J. M. De Boer[1]

- 9 to 23 g/cap/day of edible animal protein could be supplied if all types of food waste recycled as feed.
- Higher share of ruminant meat to harness feeds with low to no opportunity costs.



Nutritional contribution of ASF from livestock with low-opportunity cost feed and current ASF production to daily recommended nutrient intake. Van Zanten et al., 2018

Example in the EU: optimal conversion of low-opportunity-cost feed reduces supply by 38%

Journal of Cleaner Production 219 (2019) 485–496

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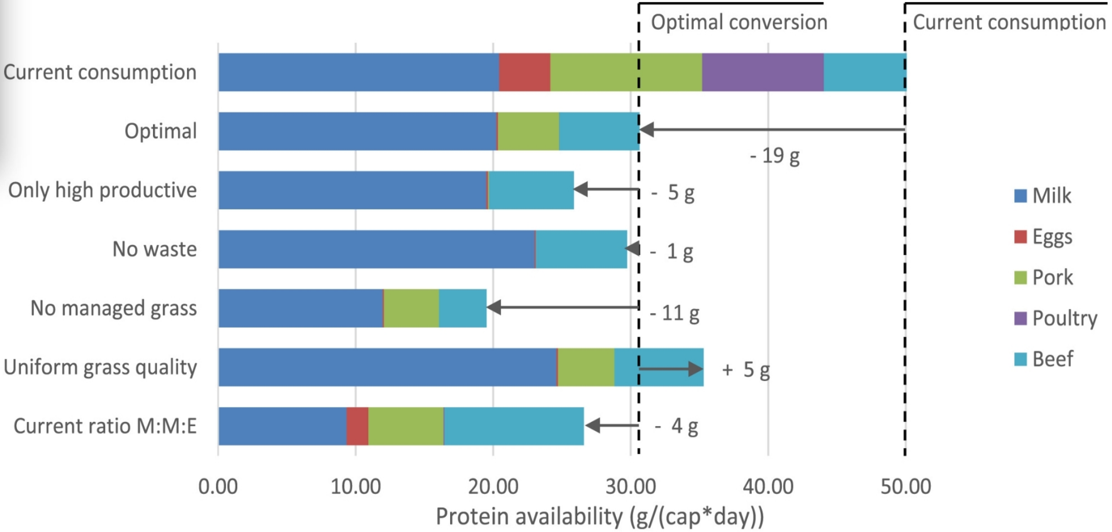
journal homepage: www.elsevier.com/locate/jclepro

Upcycling food leftovers and grass resources through livestock: Impact of livestock system and productivity

O. van Hal [a,*], I.J.M. de Boer [a], A. Muller [b], S. de Vries [c], K.-H. Erb [d], C. Schader [b], W.J.J. Gerrits [c], H.H.E. van Zanten [a]

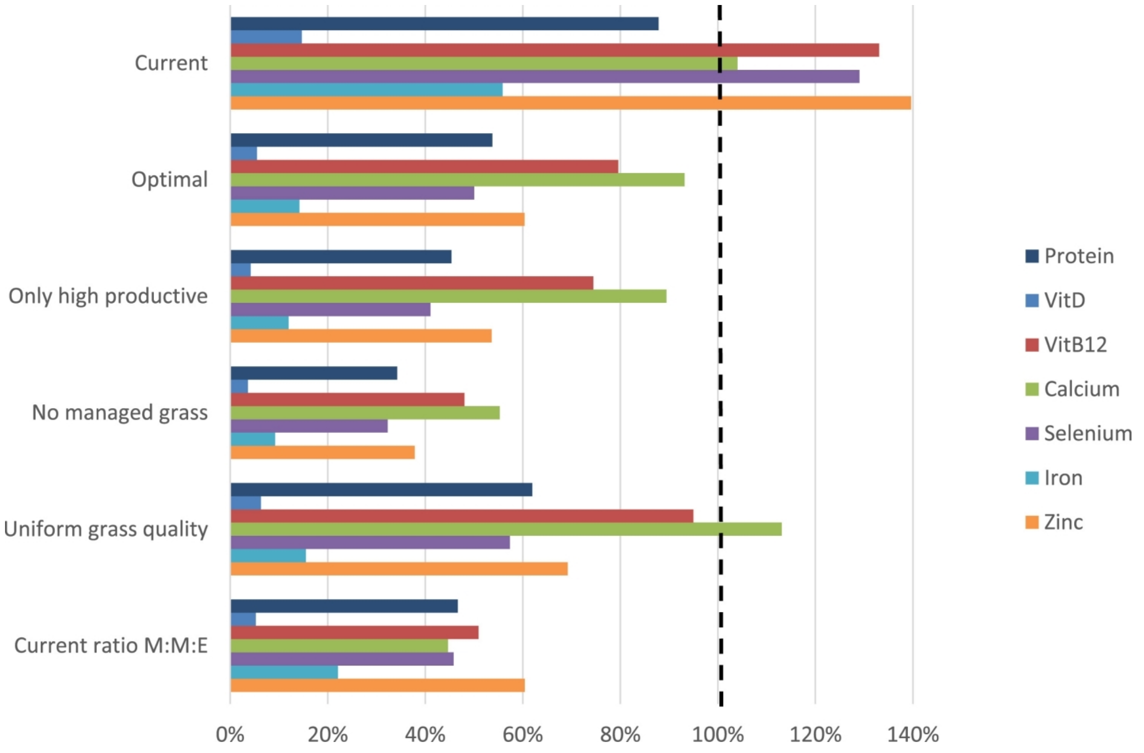


Animal human digestible protein (HDP) supply/EU cap/day

https://www.sciencedirect.com/science/article/pii/S0959652619303622

And nutrient supply also decreases

Nutrient supply/EUcap/day by ASF, relative to daily intake requirements (USDA) under optimal conversion of LCF compared with the current average European diet and alternative optimisation scenarios



https://www.sciencedirect.com/science/article/pii/S0959652619303622

Increase use of low-opportunity-cost feed in China reduces water use and GHG emissions

nature food

Article https://doi.org/10.1038/s43016-023-00813-x

Low-opportunity-cost feed can reduce land-use-related environmental impacts by about one-third in China

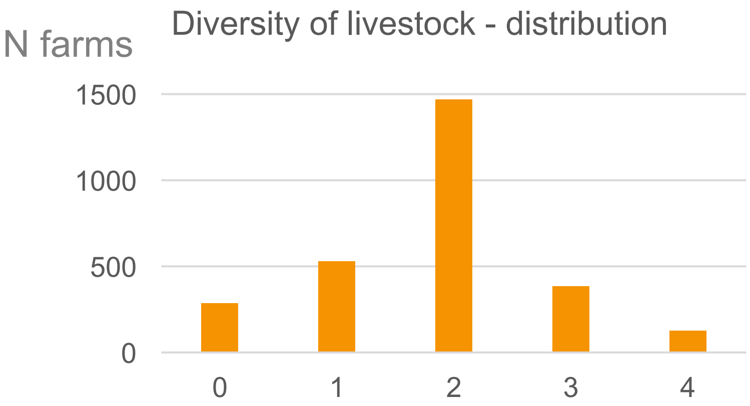
Received: 15 July 2022

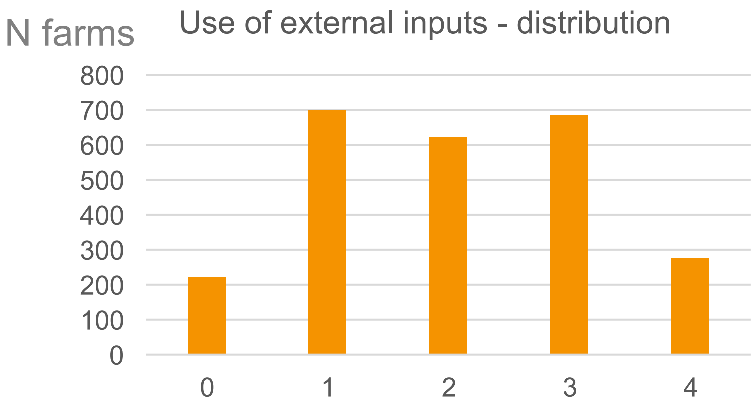
Accepted: 7 July 2023

Qunchao Fang[1], Xiaoying Zhang[1], Guichao Dai[1], Bingxin Tong[1], Hongliang Wang[1], Oene Oenema[1,2], Hannah H. E. van Zanten[3], Pierre Gerber[4,5] & Yong Hou[1]

- 1/3 of animal feed are human-edible products
- Only 23% of available LCFs used as feed (2009–2013)
- Increased utilization of LCFs (45–90 Mt) could save 25–32% of cropland area without impairing livestock productivity
- 1/3 of feed-related irrigation water, synthetic fertilizer and greenhouse gas emissions would be saved
- Re-allocation of saved cropland could sustain food energy demand of 30–185 million people
- Need improved technology and

Some insights from multicriteria assessments and agroecology in sub-Saharan Africa





0 - No animals
1 - One species
2 - Two or three species, few animals
3 – More than three species with significant number of animals
4 – More than three species, different breeds

0 - All inputs purchased from market
1 - Majority of inputs purchased from the market
2 - Some inputs produced on farm/exchanged locally
3 - Majority of inputs produced/ exchanged
4 - All inputs produced/exchanged

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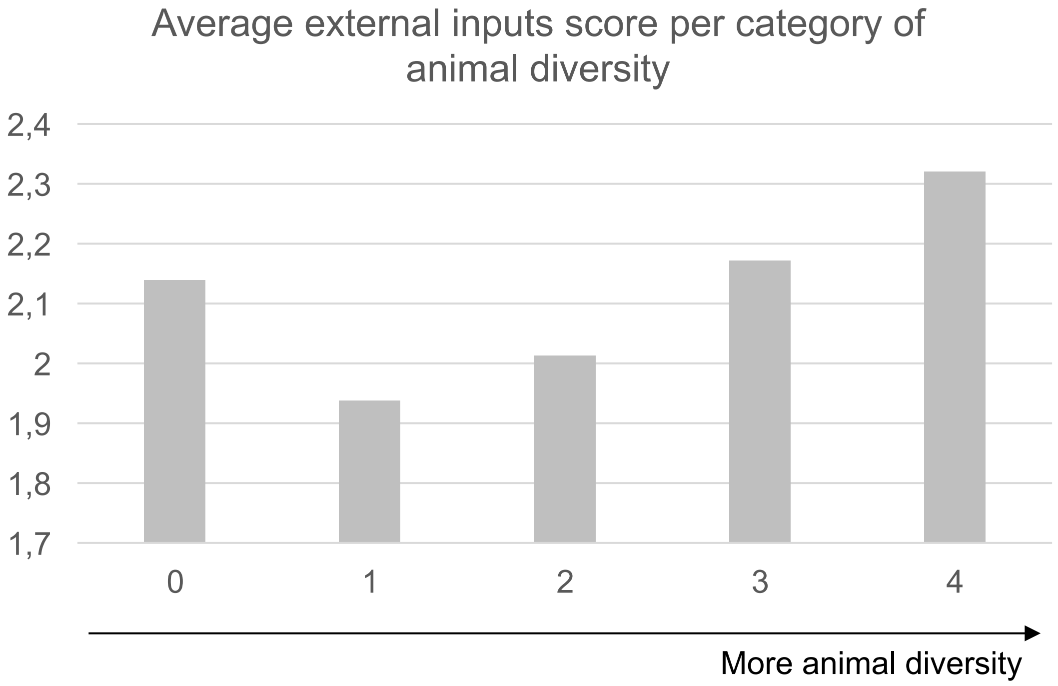
Data from FAO Tool for Agroecology Performance Evaluation
Data from c.a. 3,000 farms in 9 countries of Sub-Saharan Africa

Farms with higher animal diversity are less dependant on external inputs (except if specialised crops)

External input score measured as:

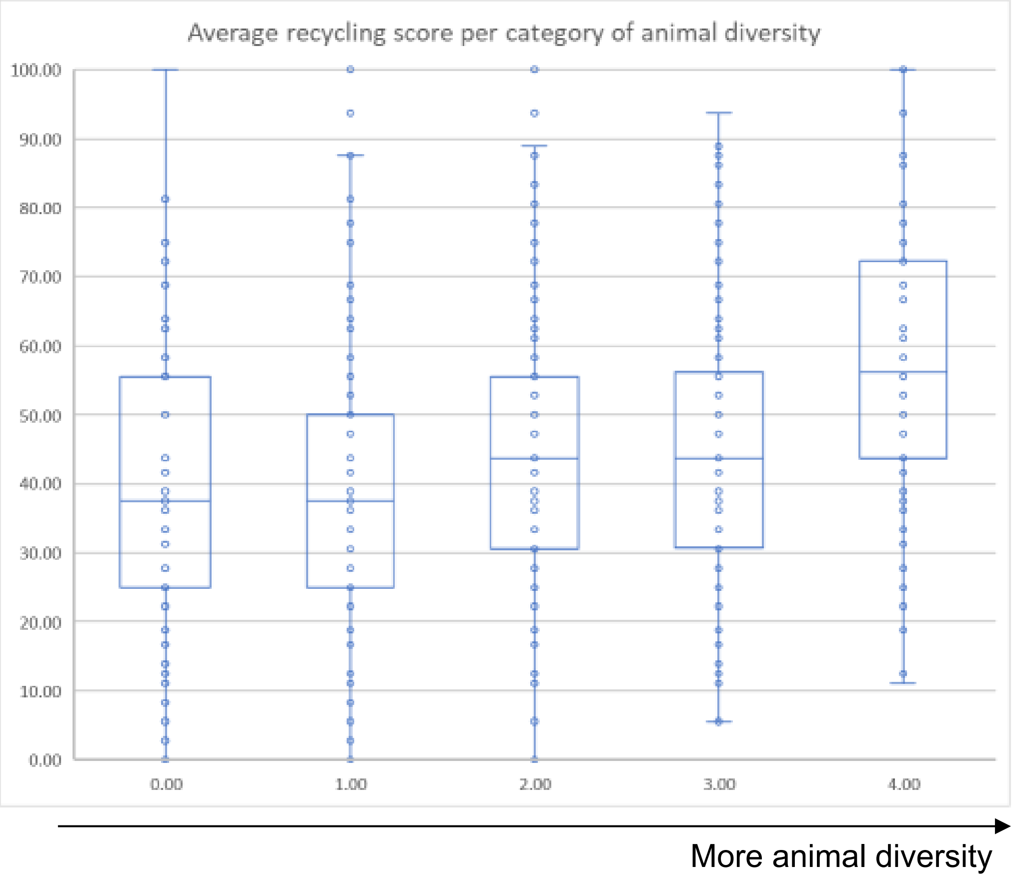
0 - All inputs purchased from market
1 - Majority of inputs purchased from the market
2 - Some inputs produced on farm/exchanged locally
3 - Majority of inputs produced/ exchanged
4 - All inputs produced/exchanged



Farms with higher animal diversity have higher scores of recycling

Recycling measured by:

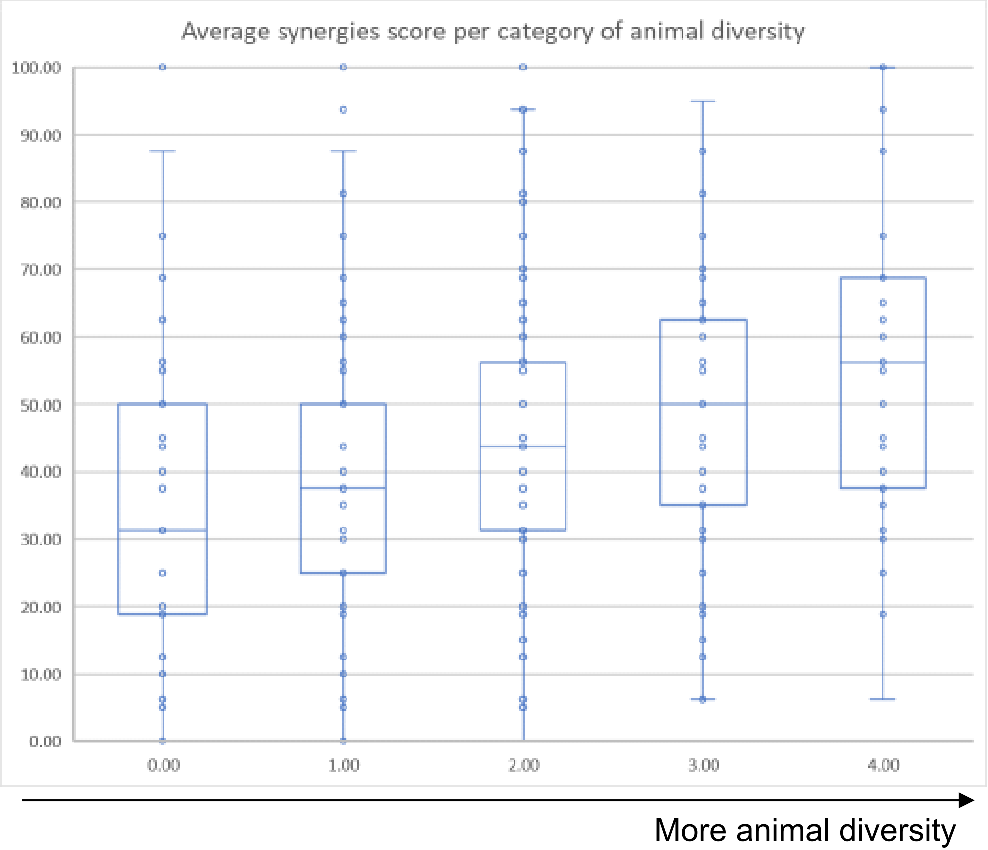
- Recycling of biomass and nutrients (crop-residues, waste etc.)
- Water saving
- Management of seeds and breeds
- Renewable energy use and production



Farms with higher animal diversity have higher scores of synergies

Synergies measured by:

- Crop-livestock-aquaculture integration
- Soil-plants system management
- Integration with tree (agroforestry, silvopastoralism, agrosilvopastoralism)
- Connectivity between elements of the agroecosystem and the landscape



Upscaling circularity: Investments in small livestock production in the IFAD portfolio (1/2)

ReLIV: USD 100M in dairy and beef value chains in Uganda (200,000 households, 40% women and 25% youth) – in prep.

- Choppers for crop residues and other fodder preparation/conservation techniques (also increases digestibility)
- Improve seed selection and distribution, especially legumes and drought resistant species/varieties
- Capacity development and equipment in farms for better milk hygiene
- Capacity development and equipment in milk collection centers for improved milk transport and conservation as well as recycling of waste
- Development of a quality based payment scheme
- Policy support (e.g. revision of the National Feed Policy)

Upscaling circularity: Investments in small livestock production in the IFAD portfolio (2/2)

Dairy Value Chains Development Project: USD 39M in dairy value chains in Uzbekistan (20,000 households, 40% women and 30% youth) – completed, second phase in prep.

- Availability of land for fodder production is a major constraint → develop capacity for production of fresh and conserved fodder (yield increase 20%) and preparing high energy feed using hay, concentrate, silage and minerals
- Training on improved manure management and nitrogen cycles
- Development of milk collection centers and funding of milk storage and processing equipment and support to
- Support access to credit

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Conclusions: how to improve circularity?

- Assess the amount of biomass that can be potentially recycled as livestock feed and the impact of recycling on productivity
- Research and regulation to address externalities and existing subsidies on inputs (e.g., fossil fuels or fertilizers)
- Difficulties in adapting technical solutions to location-specific conditions, and lack of access to knowledge and technologies → Invest at all levels of the value chain to upscale solutions!
- Address the impact on products, including seasonality of supply
- Need regulatory frameworks including technical requirements for more nonedible products in livestock feed and potential health trade-offs. E.g. Japan: policies, including certification system and mandatory heat treatment

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Thank You

31 August 2023