# What is sustainability of food and feed?

Anne Mottet

Lead Livestock Specialist

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# What is at stake ?

| | Food security and nutrition | Livelihoods and economic growth | Health and animal welfare | Climate and natural resource use |
|---|---|---|---|---|
| Food | • Eradicate hunger, micronutrient deficiency and overconsumption with nutrient dense ASF<br>• Inequality in access to nutritious food<br>• Reduce food loss and waste | • Employment in food systems<br>• Equity (gender, small holders)<br>• Affordability of healthy diets<br>• Self-sufficiency/food sovereignty vs globalised food systems | • Food-borne diseases<br>• Malnutrition and NCD | • Reduce vulnerability and exposure of food systems to climate risks<br>• Reduce GHG emissions of diets and use of natural resources<br>• Alternative proteins |
| Feed | • Feed/food competition (for land, water, energy)<br>• Large ranges of feed use efficiency<br>• Recycling biomass<br>• Feed quality and feed safety | • Global economy and volatility in cost of production | • Interaction with wildlife (extensive grazing systems)<br>• More exposed to disease outbreaks? (backyard)<br>• AMR | • Reduce deforestation due to pasture and feed crops expansion<br>• Alternative feed |

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*Framework adopted for GFFA 2018, GASL, and FAO Sub-Committee on Livestock 2021, as well as for the study "Future of EU Livestock: how to contribute to a sustainable agricultural sector?"*

# Future global food production: we will need more of everything!

| Scenarios 2012-2050 | BAU | Towards Sustainability | Stratified Societies |
|---|---|---|---|
| Cereals | +54% | +39% | +56% |
| Meat | +52% | +29% | +55% |
| Dairy | +40% | +35% | +45% |
| Eggs | +39% | +25% | +40% |
| Fish | +35% | +37% | +35% |
| Oilseeds | +50% | +40% | +51% |
| Fruits and vegetables | +49% | +48% | +54% |
| Cash crops | +44% | +39% | +53% |

*Source: The future of food and agriculture. FAO, 2018*

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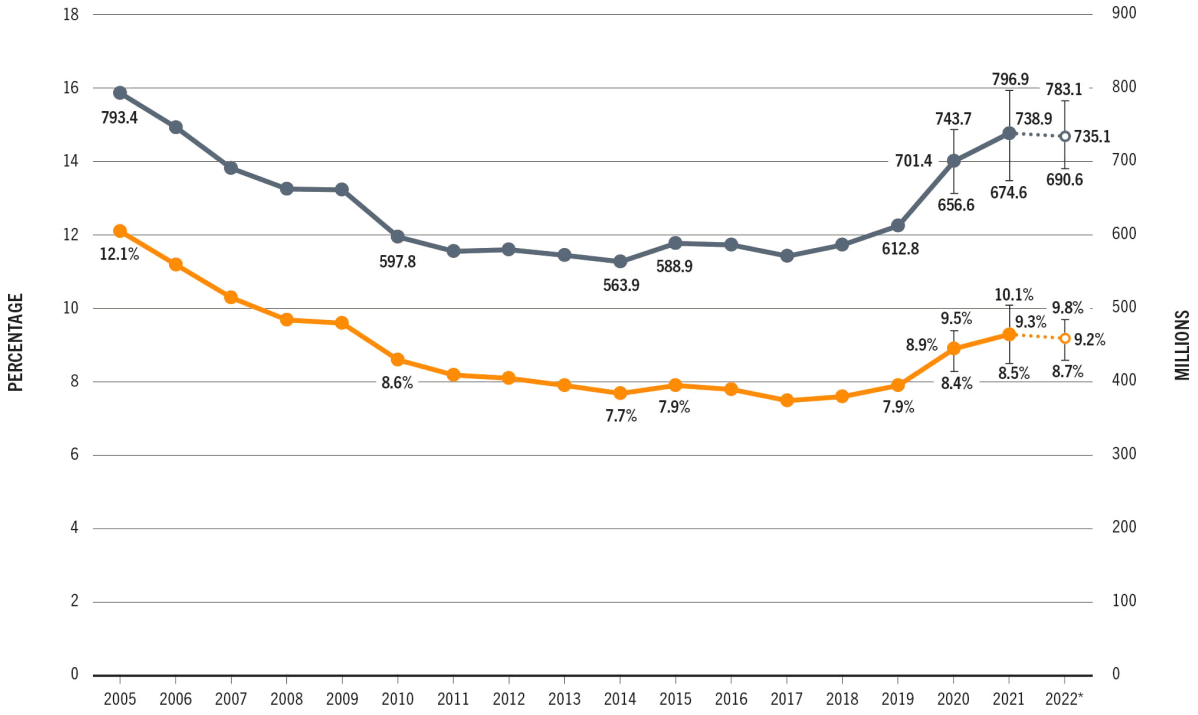
# The state of food security: hunger is on the rise

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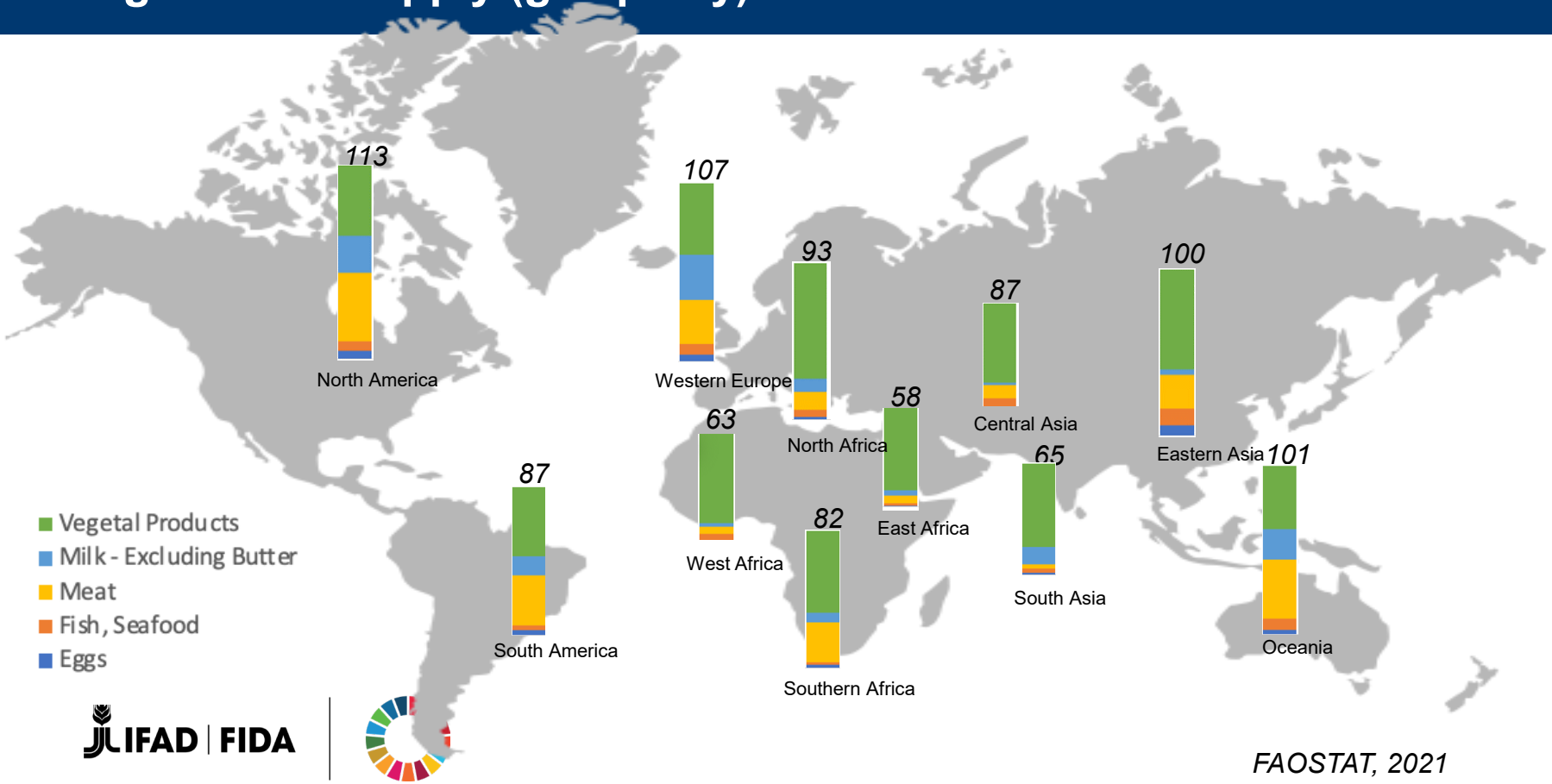
https://www.fao.org/3/CC3017EN/online/state-food-security-and-nutrition-2023/food-security-nutrition-indicators.html

# Strong inequalities in access to food
# e.g. Protein supply (g/cap/day)

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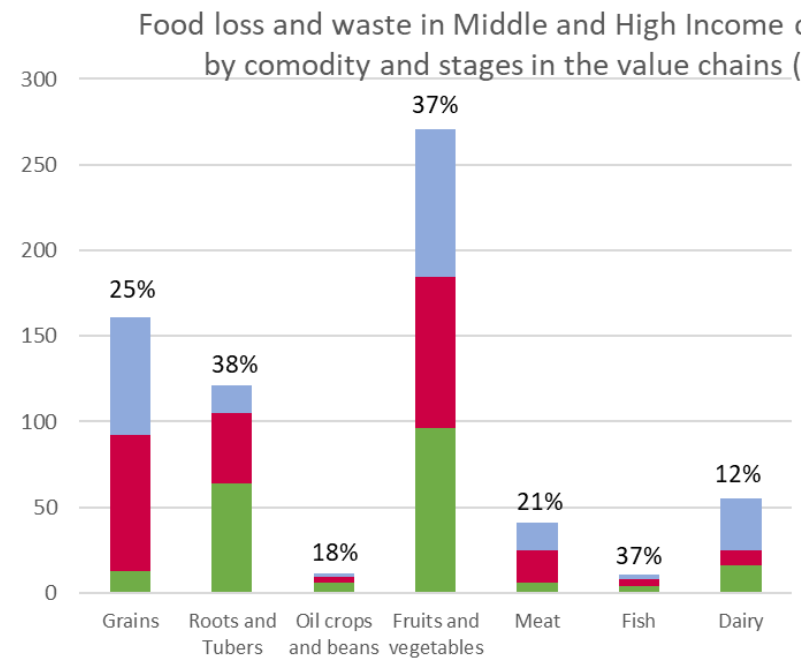
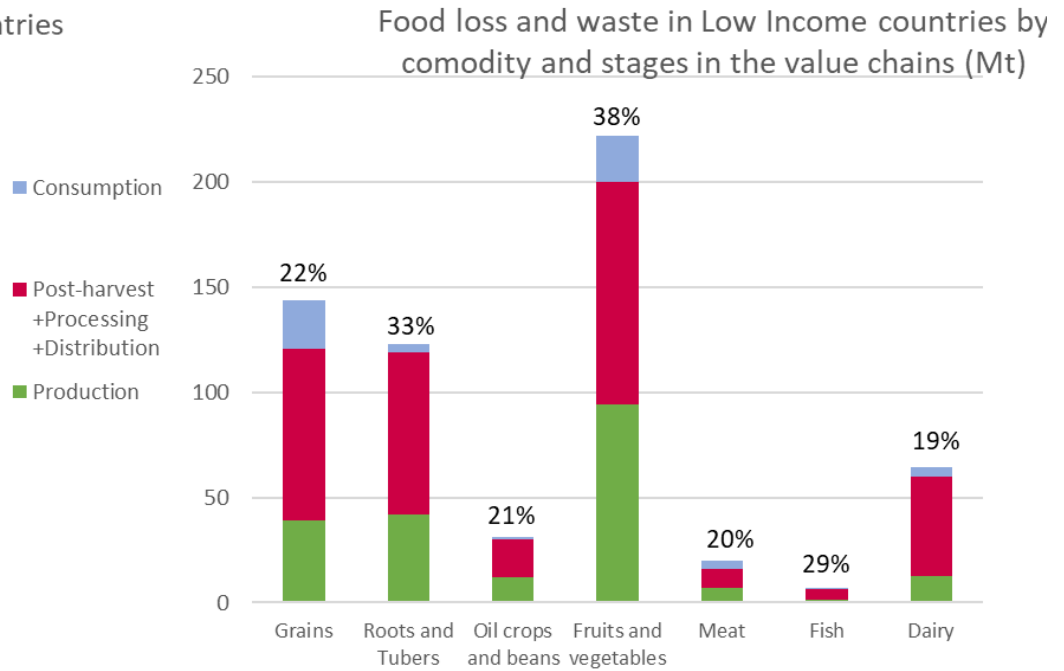
*FAOSTAT, 2021*

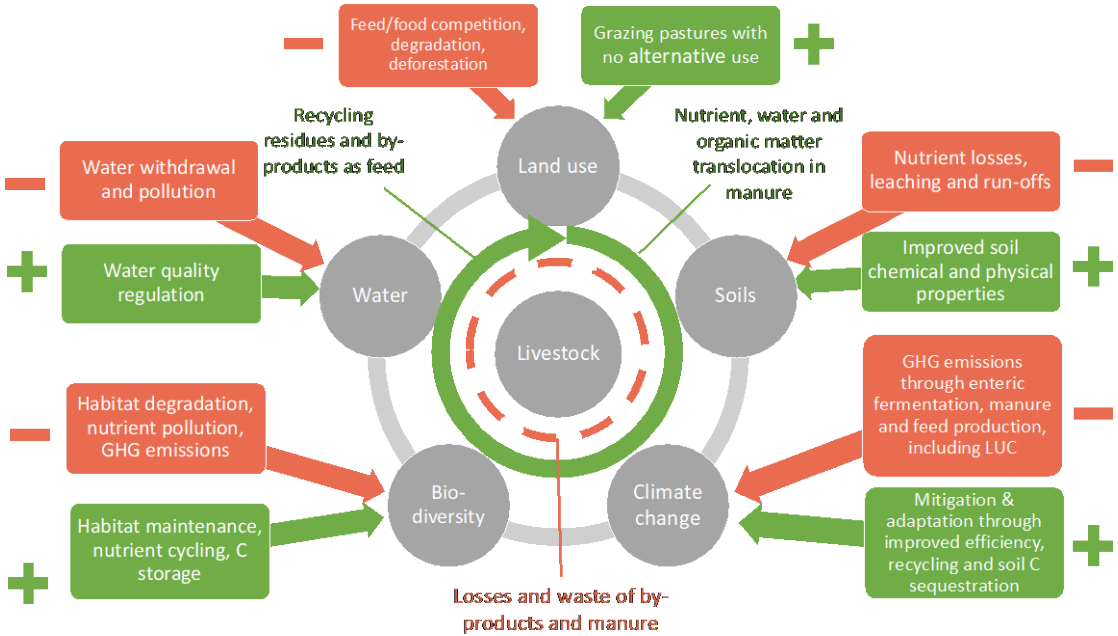
# Food loss and waste. Where do they happen?




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

# Environmental sustainability of food and feed: circularity can limit negative impacts and enhance positive ones




Climate and natural resource use


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

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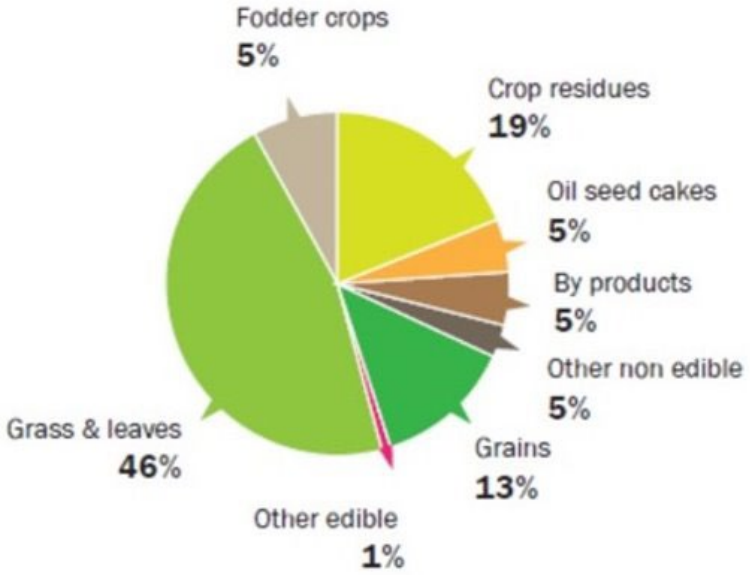
# Circularity

**Global livestock feed rations**




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

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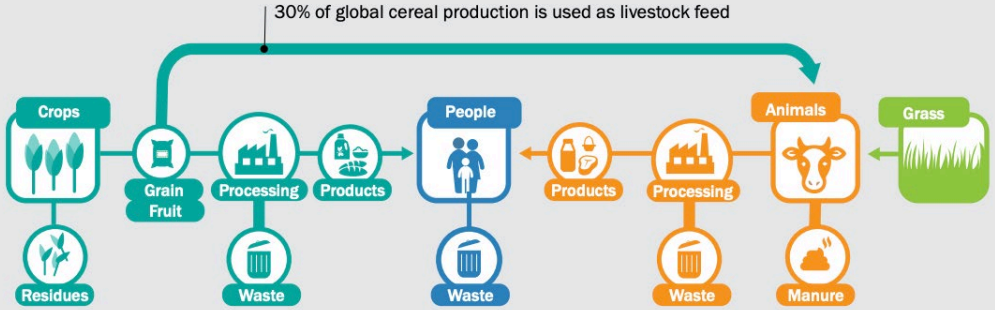
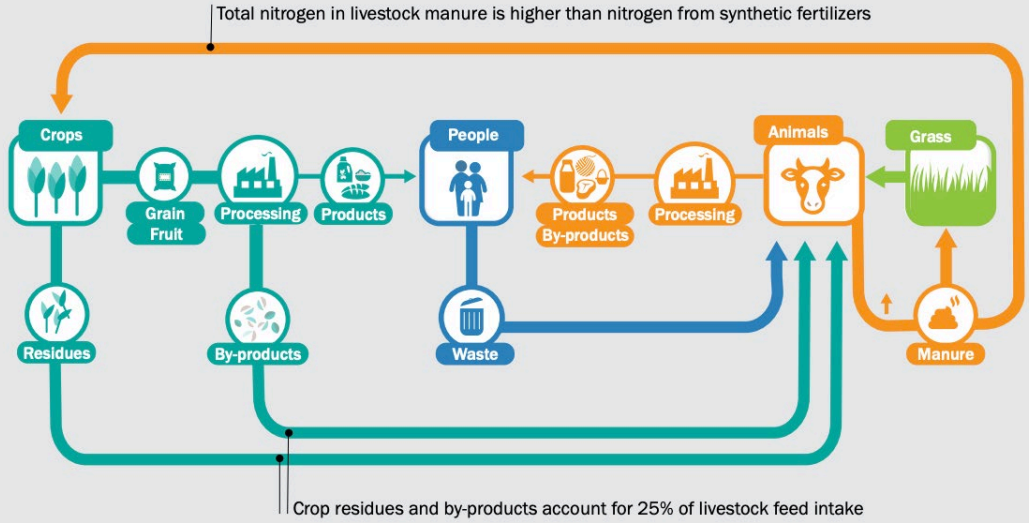
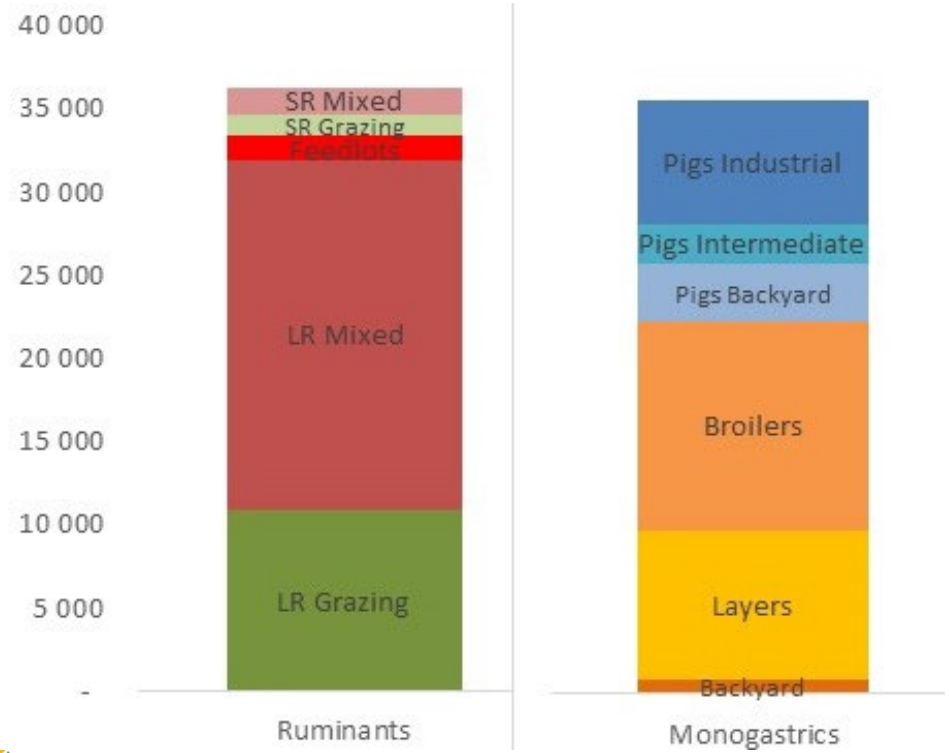
LINEAR




CIRCULAR



# Total protein production of livestock systems (Mt/y)




Source: Mottet et al. (2017) 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 |

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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 |

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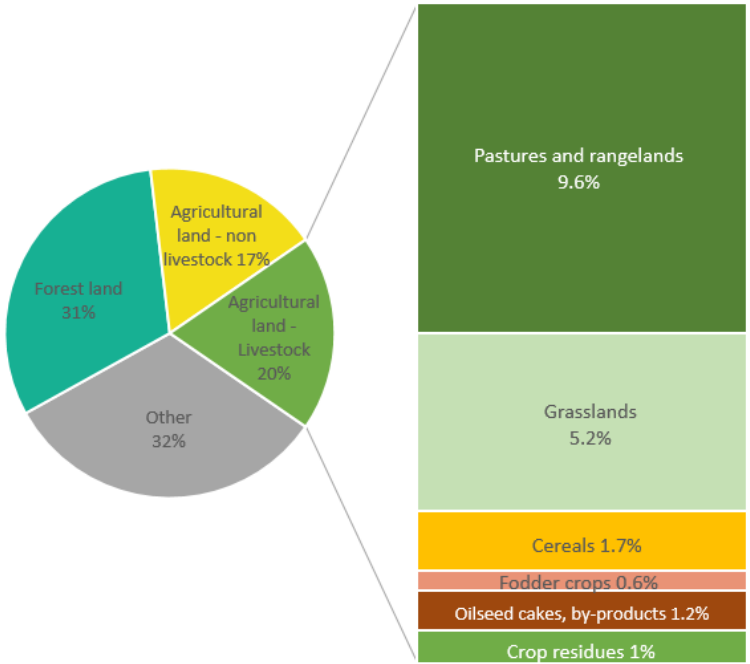
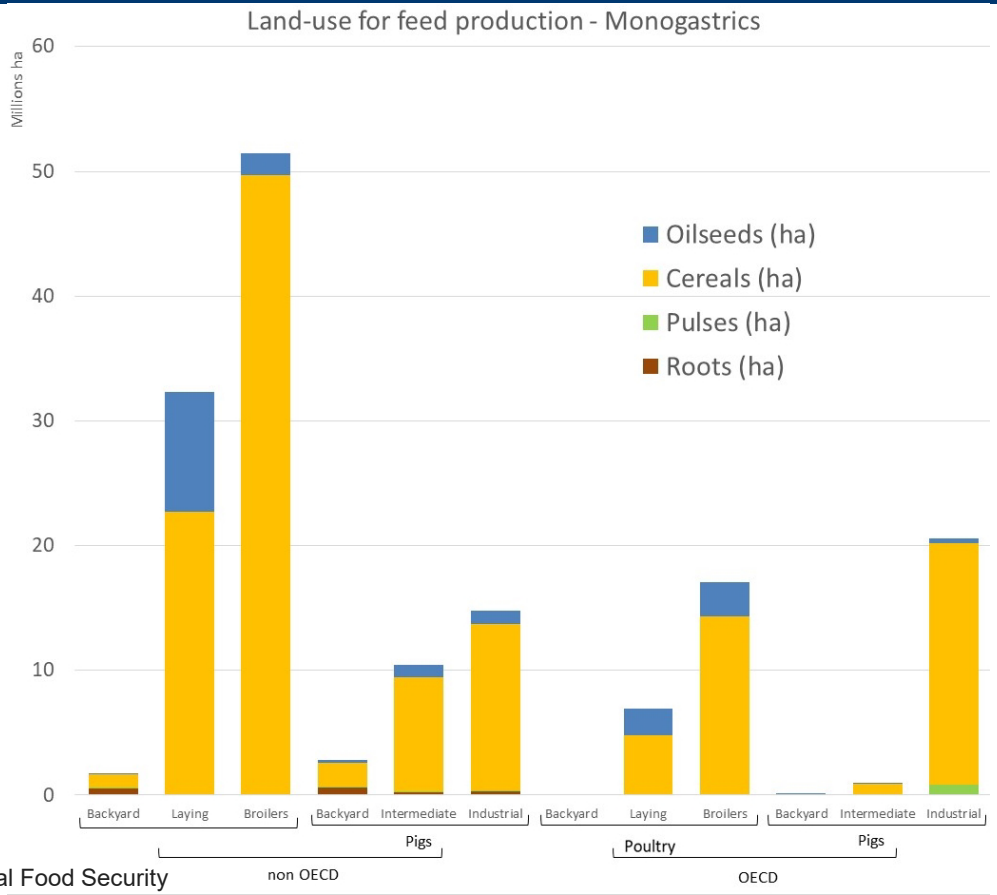
Source: Mottet et al. (2017) Global Food Security

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




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

# Example in the EU

Journal of Cleaner Production 219 (2019) 485–496

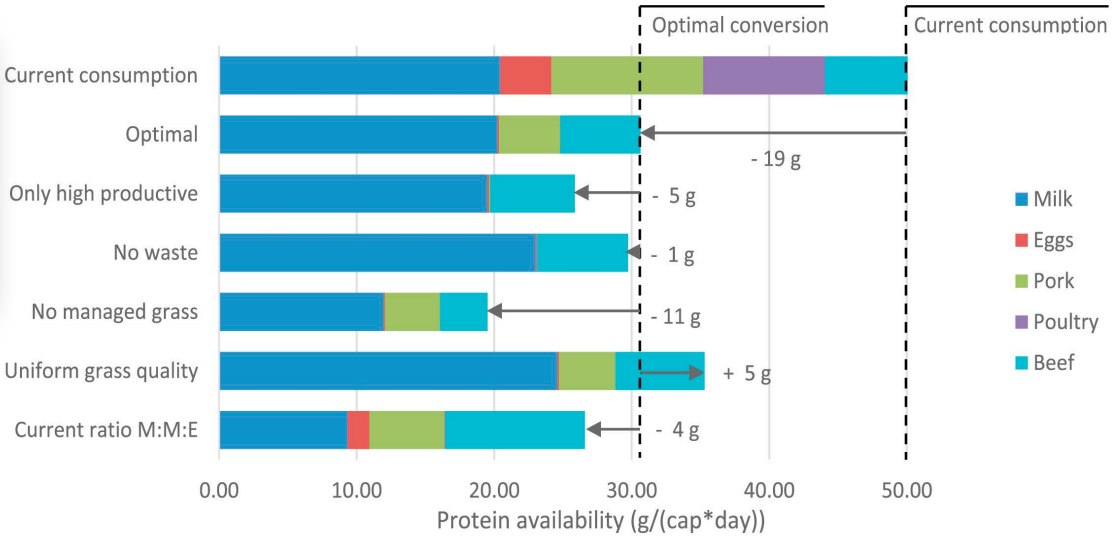
Contents lists available at ScienceDirect

Journal of Cleaner Production

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]

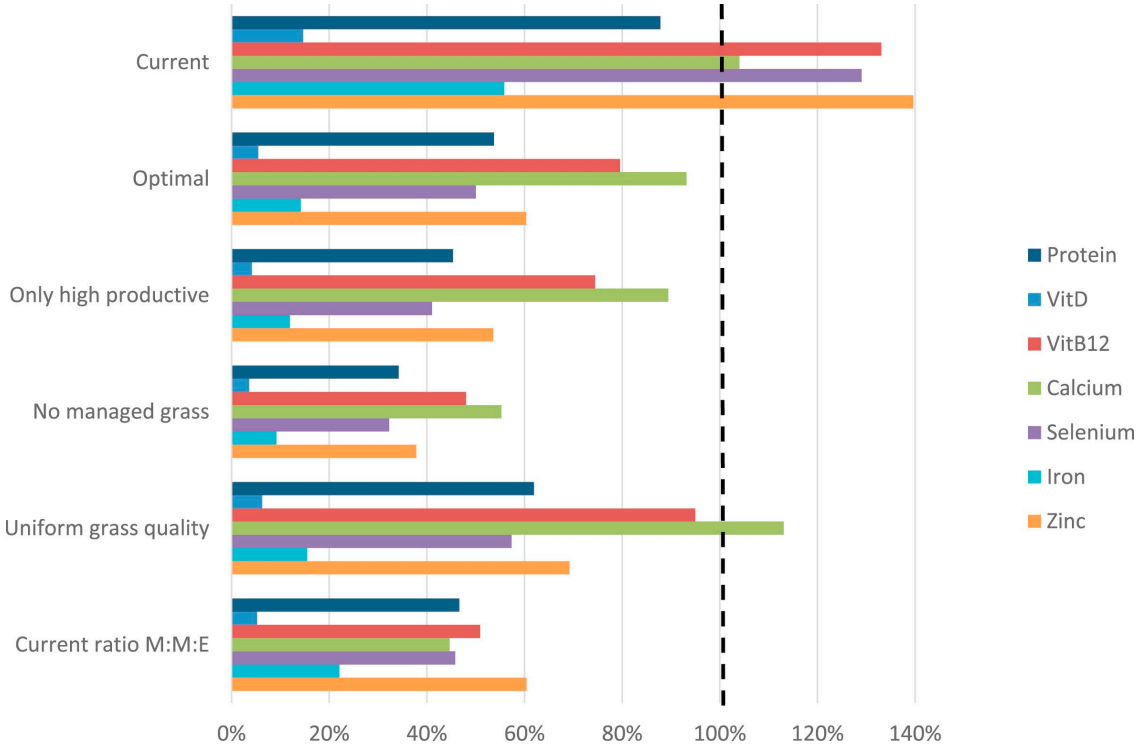



Animal human digestible protein (HDP) supply, per EU capita per day, under optimal conversion of LCF compared with current animal HDP consumption, and alternative optimisation scenarios of the sensitivity analysis

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

# Example in the EU

Nutrient supply by ASF, per EU capita per day, 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

# Example in China

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 the 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
- Achieving the potentials of increased LCF use requires improved technology and coordination among stakeholders.

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# Insects for food and feed

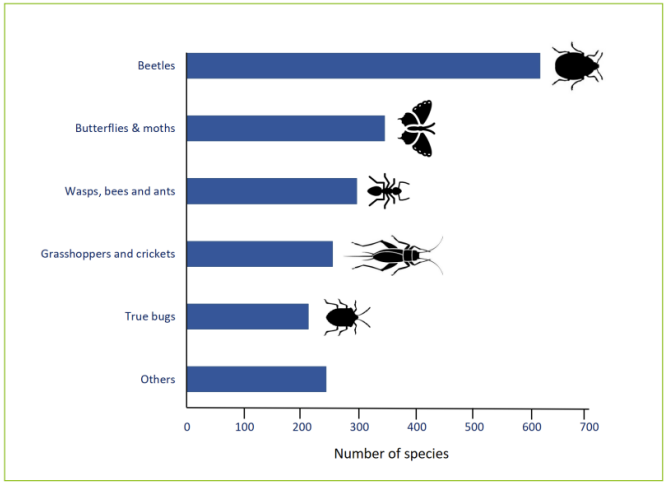


**Figure 1:** Number of edible insect species known for five insect orders and the remaining number of edible insect species belonging to other orders[2].

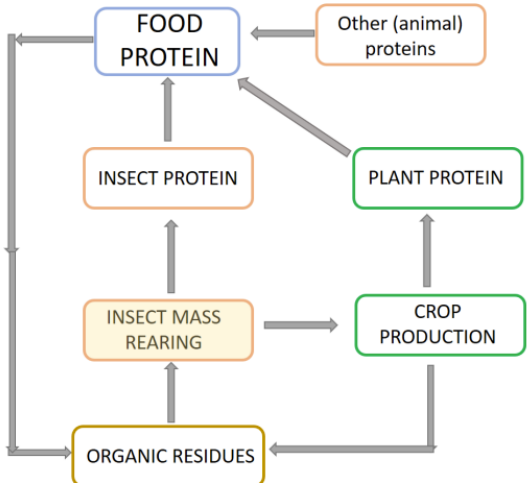


**Figure 2:** Insect protein production as central component in a circular food system as outlined in the text.

Pyett et al., 2023. Our Future Protein

- Global mass production of edible insects for both food and animal feed was estimated at 10,000 metric tons in 2020, most of which is used in animal feed.
- Impact of mass production on food/feed safety and on biodiversity are still mostly unknown

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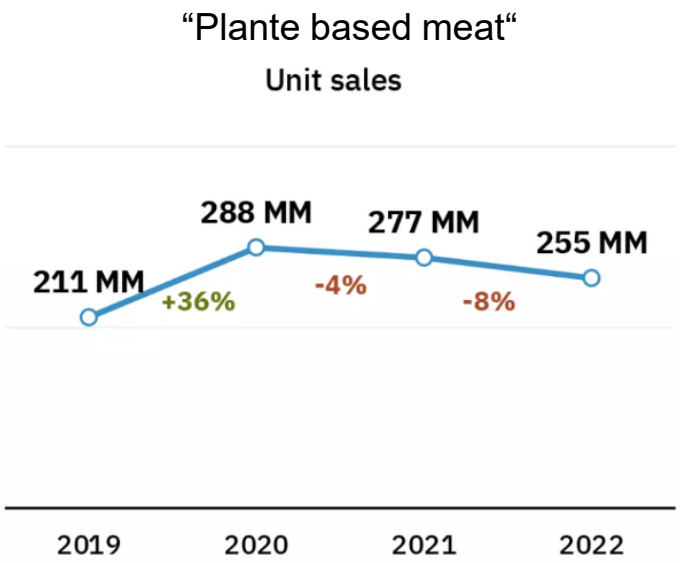
# Cellular food

- Livelihoods/economy: Large investments and companies in the US and the EU, non-relevance or even threat for small-scale farmers
- Food security and nutrition: Still virtually no market (only a few countries with authorisation and no production at scale). Cell culture technology still needs to be optimized and nutrition better understood
- Health and welfare: considerably fewer animal required but still need bovine serum as growth media. High risks of contamination and requires biopharmaceutical standards
- Environment: Considerably less land but high energy requirements to maintain temperature (recent studies consider no gain in GHG emissions)

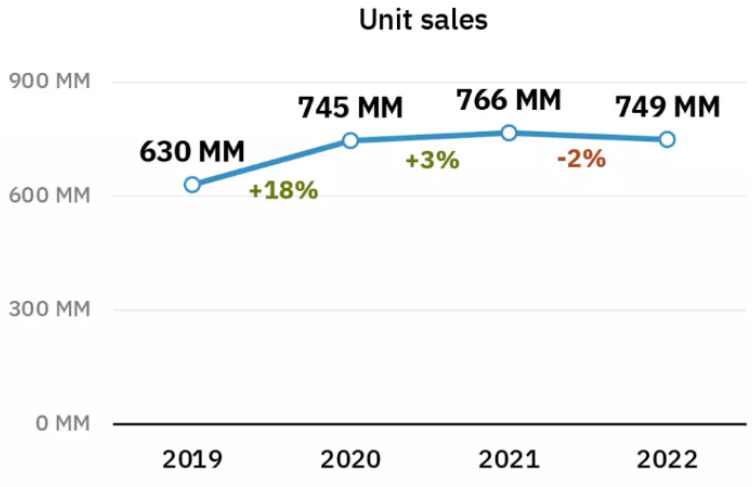
# Plant-based meat and milk substitutes

“Plante based meat“




-19% July 2023
Decrease also in EU

“Plante based milk“



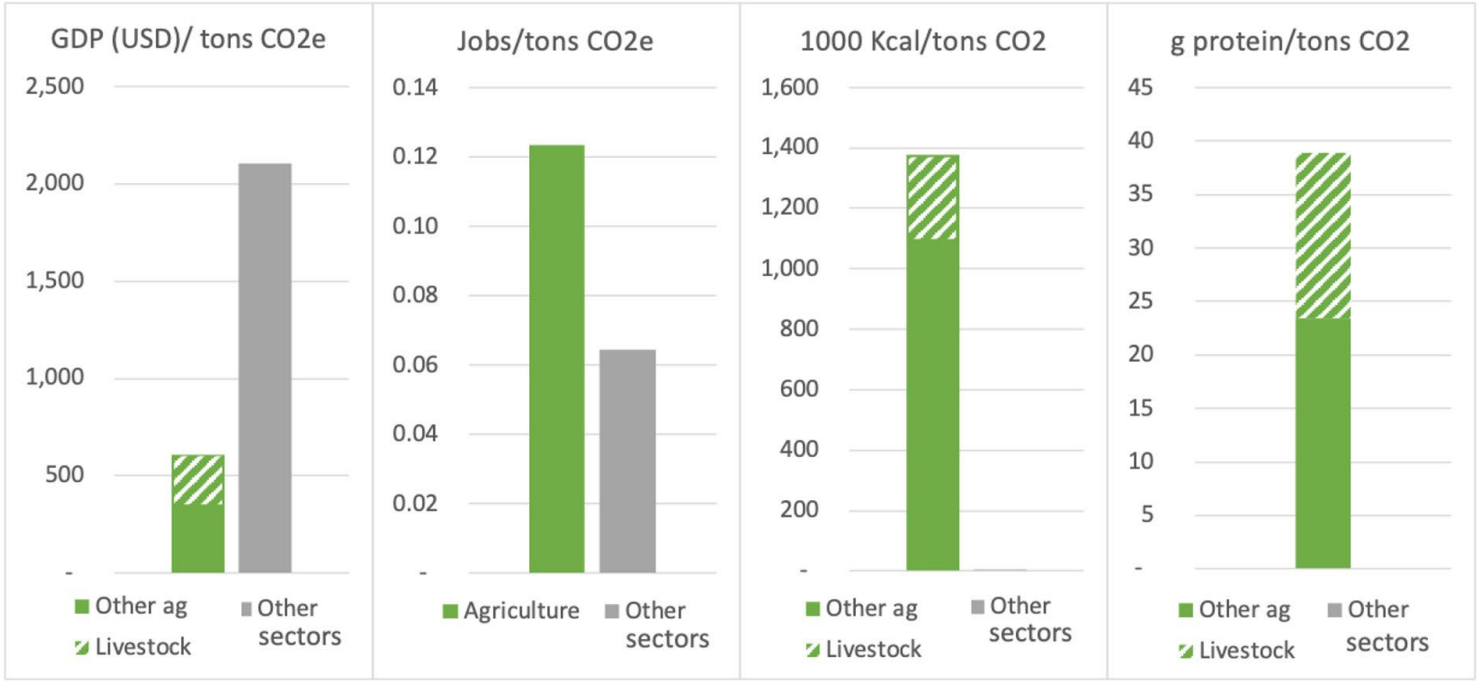

Source https://gfi.org/marketresearch/

# Other sources, mostly as food ingredients

- Microalgae (e.g. spirulina). About 20,000t/year. Still higher cost (15-25 euros/kg)
- Mycoproteins
- Yeast proteins and precision fermentation
- Extraction and co-products (e.g. potato protein, green leaves etc.)

From Pyett et al., 2023. Our Future Protein

# What do we get from a ton of $CO_2$ equivalent emitted? It's not only about food!

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Source: Authors, using World Bank and FAOSTAT data
Non-agricultural emissions of low-income countries missing

# Nutritional functional units (including variability across production systems) to inform decision makers and consumers

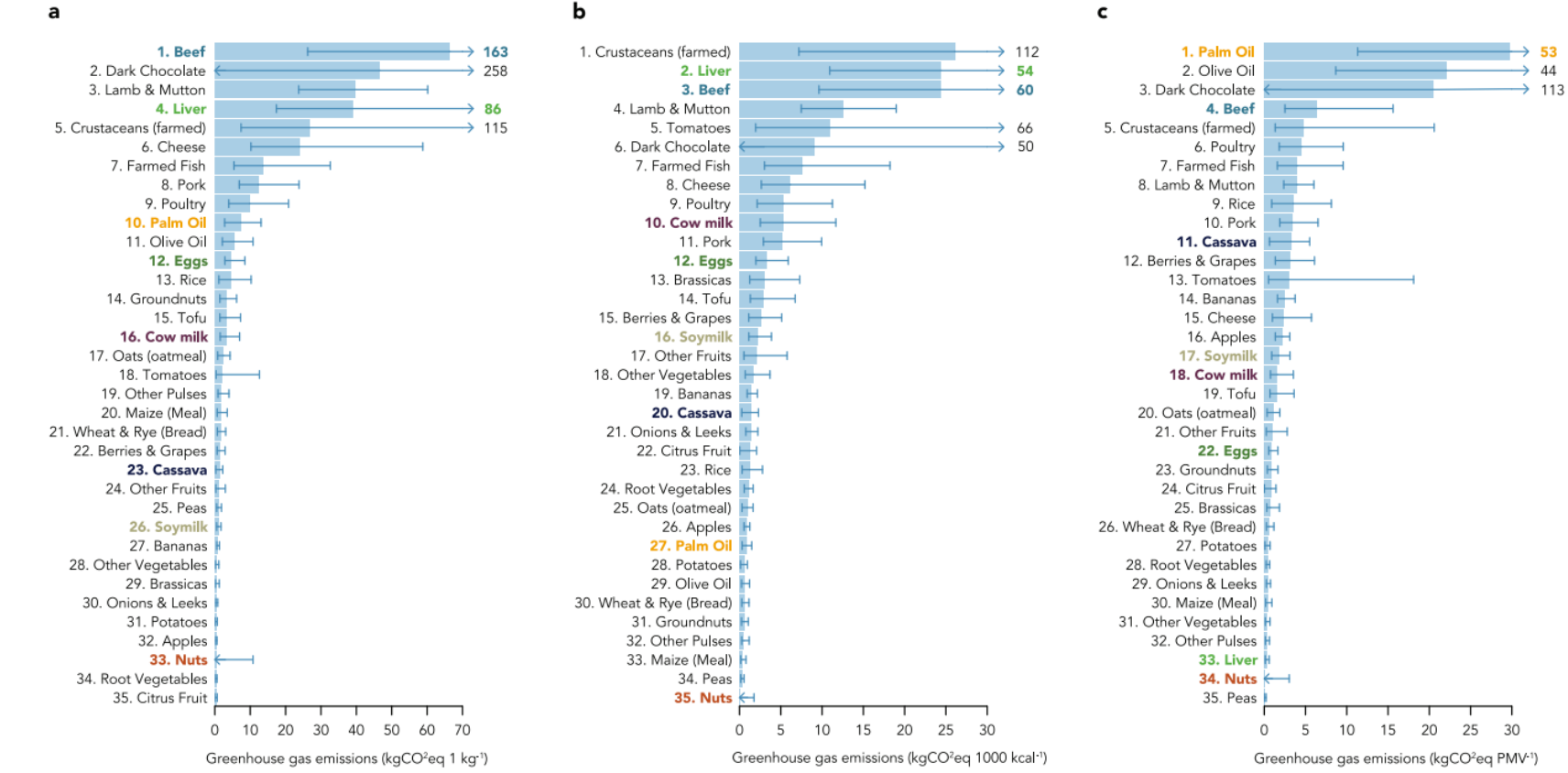


**Fig. 3 Foods ranked by carbon footprint, levelled for weight, energy, and priority micronutrient value** https://www.nature.com/articles/s43247-023-00945-9

# Ranking

Foods are not ranked the same way if we look at GHG emissions, land-use, water withdrawals, acidification and eutrophication. For instance, nuts rank consistently as one of the least GHG-intensive foods regardless of which functional unit is used, but rank much less favorably when it comes to their water footprint

| Rank | Land Use footprint ($m^2$*yr to obtain PMV) | Carbon footprint (kg CO2eq to obtain PMV) | Freshwater withdrawals (L to obtain PMV) | Acidification potential (g $SO_2$eq to obtain PMV) | Eutrophication potential (g $PO_4^{3-}$eq to obtain PMV) |
|---|---|---|---|---|---|
| Highest Footprint 1 | Olive Oil | Palm Oil | Olive Oil | Olive Oil | Olive Oil |
| 2 | Lamb & Mutton | Olive Oil | Rice | Palm Oil | Farmed Fish |
| 3 | Dark Chocolate | Dark Chocolate | Nuts | Poultry | Palm Oil |
| 4 | Beef | Beef | Farmed Fish | Pork | Crustaceans (farmed) |
| 5 | Palm Oil | Crustaceans (farmed) | Apples | Beef | Dark Chocolate |
| 6 | Cheese | Poultry | Berries & Grapes | Berries & Grapes | Beef |
| 7 | Poultry | Farmed Fish | Crustaceans (farmed) | Tomatoes | Rice |
| 8 | Bananas | Lamb & Mutton | Cheese | Crustaceans (farmed) | Poultry |
| 9 | Berries & Grapes | Rice | Tomatoes | Rice | Pork |
| 10 | Pork | Pork | Groundnuts | Dark Chocolate | Berries & Grapes |
| 11 | Cow milk | Cassava | Pork | Farmed Fish | Tomatoes |
| 12 | Cassava | Berries & Grapes | Bananas | Bananas | Lamb & Mutton |
| 13 | Nuts | Tomatoes | Cow milk | Apples | Cheese |
| 14 | Oats (oatmeal) | Bananas | Poultry | Cheese | Bananas |
| 15 | Apples | Cheese | Wheat & Rye (Bread) | Lamb & Mutton | Apples |
| 16 | Farmed Fish | Apples | Dark Chocolate | Nuts | Brassicas |
| 17 | Groundnuts | Soymilk | Oats (oatmeal) | Brassicas | Nuts |
| 18 | Other Pulses | Cow milk | Beef | Eggs | Cow milk |
| 19 | Rice | Tofu | Lamb & Mutton | Cow milk | Oats (oatmeal) |
| 20 | Citrus Fruit | Oats (oatmeal) | Citrus Fruit | Citrus Fruit | Citrus Fruit |
| 21 | Tofu | Other Fruits | Brassicas | Cassava | Eggs |
| 22 | Wheat & Rye (Bread) | Eggs | Other Fruits | Groundnuts | Groundnuts |
| 23 | Eggs | Groundnuts | Eggs | Other Fruits | Potatoes |
| 24 | Soymilk | Citrus Fruit | Tofu | Wheat & Rye (Bread) | Tofu |
| 25 | Tomatoes | Brassicas | Other Pulses | Oats (oatmeal) | Onions & Leeks |
| 26 | Liver | Wheat & Rye (Bread) | Other Vegetables | Soymilk | Wheat & Rye (Bread) |
| 27 | Peas | Potatoes | Potatoes | Other Vegetables | Other Pulses |
| 28 | Potatoes | Root Vegetables | Maize (Meal) | Potatoes | Other Fruits |
| 29 | Other Fruits | Onions & Leeks | Soymilk | Other Pulses | Soymilk |
| 30 | Brassicas | Maize (Meal) | Peas | Onions & Leeks | Root Vegetables |
| 31 | Maize (Meal) | Other Vegetables | Root Vegetables | Tofu | Cassava |
| 32 | Crustaceans (farmed) | Other Pulses | Palm Oil | Root Vegetables | Other Vegetables |
| 33 | Onions & Leeks | Liver | Onions & Leeks | Maize (Meal) | Liver |
| 34 | Root Vegetables | Nuts | Liver | Liver | Maize (Meal) |
| Lowest Footprint 35 | Other Vegetables | Peas | Cassava | Peas | Peas |

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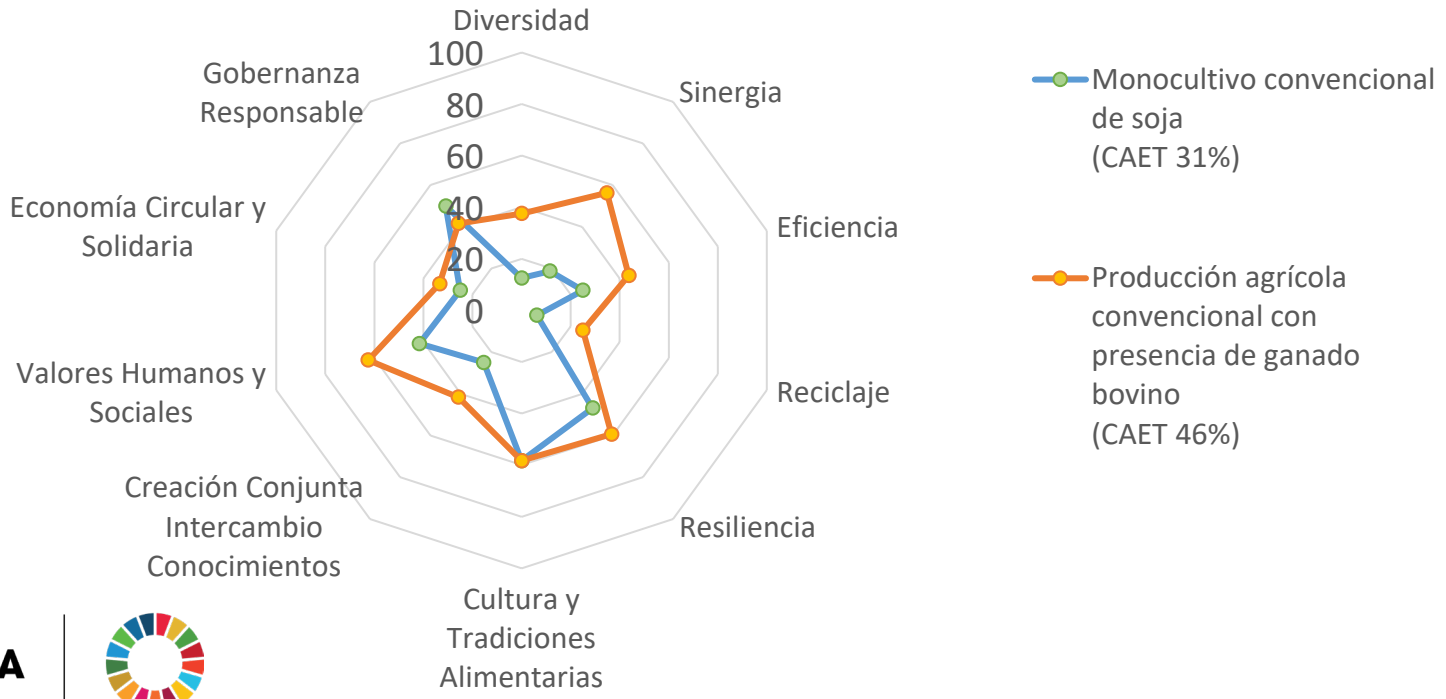
# From single metrics to multicriteria assessment using agroecology: Farms with animals are more advanced in their transition (1/2)

Results of TAPE from about 60 farms in Argentina (Rosario)

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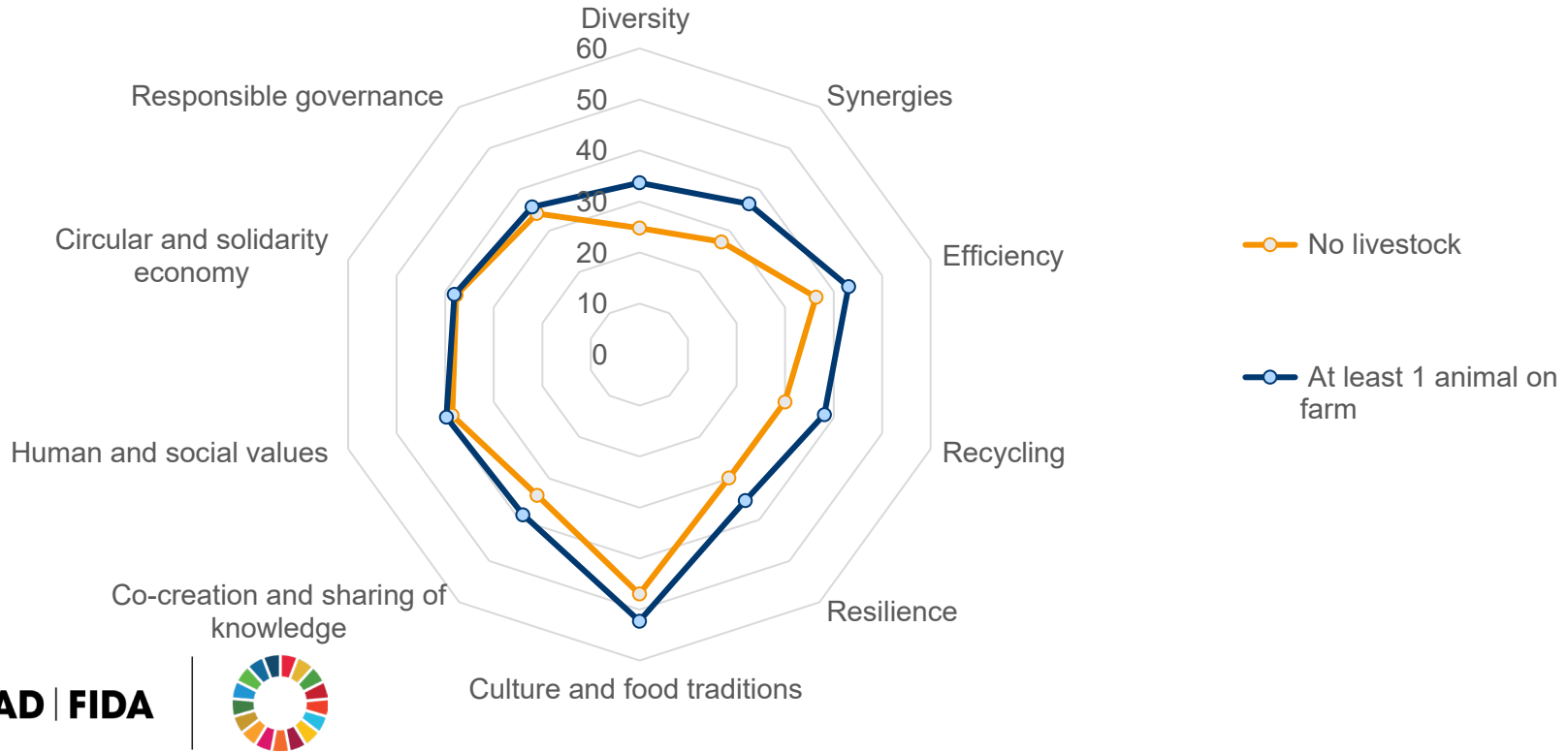
# From single metrics to multicriteria assessment using agroecology: Farms with animals are more advanced in their transition (2/2)

Results of TAPE from about 600 farms in Ethiopia

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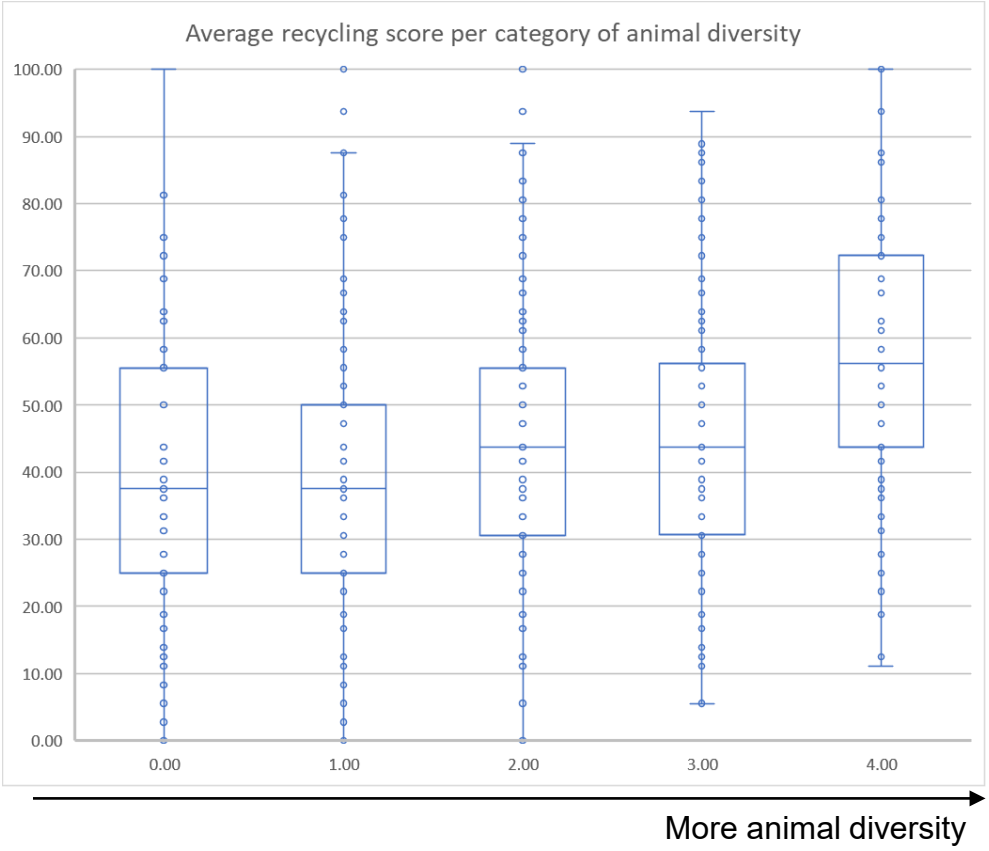
# Farms with higher animal diversity have higher scores of recycling

Recycling measured in TAPE by:

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

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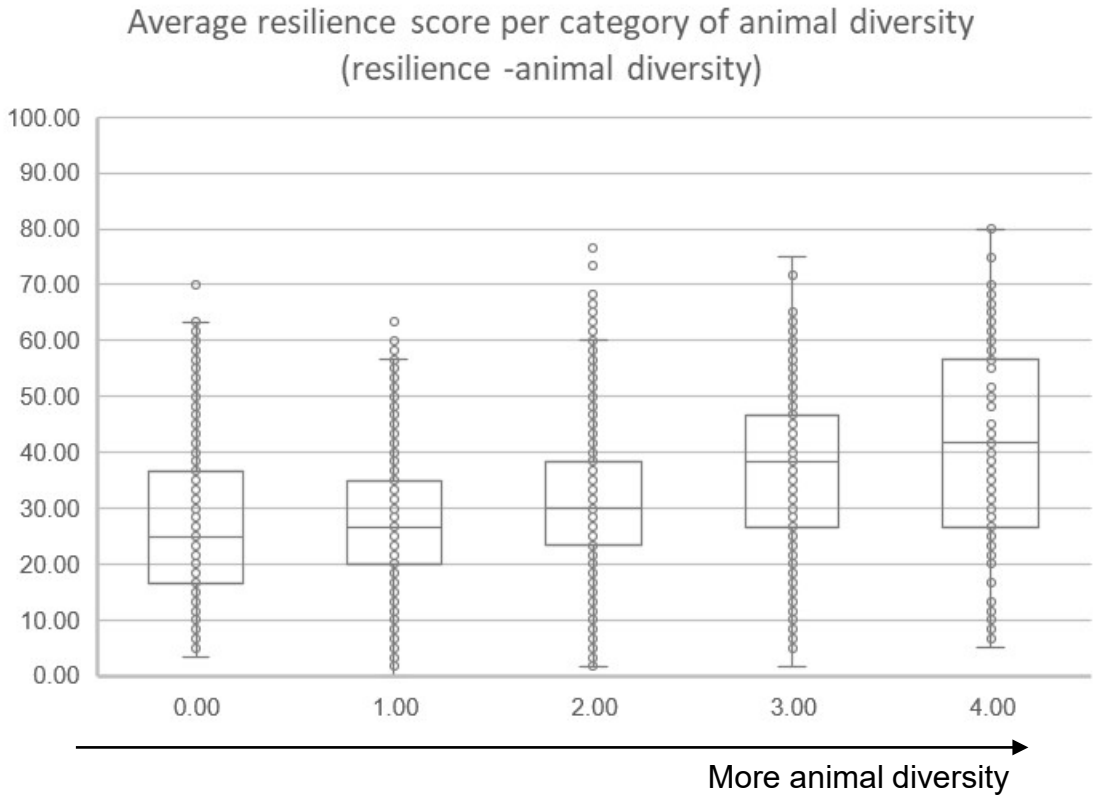
# Farms with higher animal diversity have higher scores of resilience

Resilience measured in TAPE by:

- Stability of income/production + capacity to recover
- Existence of social mechanisms to reduce vulnerability
- Environmental resilience + capacity to adapt to climate change
- Diversity of production and sources of incomes

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# We need to invest in small scale livestock for sustainability!

| | Entire IFAD portfolio (including closed projects) | | | Ongoing IFAD portfolio | | | |
|---|---|---|---|---|---|---|---|
| | Total no. of projects | No. of projects with livestock | % of projects with livestock | Total no. of projects | %. of projects with livestock | Current financing (USD million) | % of livestock Investment |
| **Asia and the Pacific** | 606 | 111 | 18% | 59 | 10% | 2 692 | 3% |
| **Eastern and Southern Africa** | 458 | 65 | 14% | 48 | 13% | 2 200 | 5% |
| **Latin America and the Caribbean** | 425 | 18 | 4% | 34 | 12% | 473 | 7% |
| **Near East and North Africa** | 448 | 94 | 21% | 29 | 28% | 883 | 3% |
| **Western and Central Africa** | 515 | 61 | 12% | 61 | 16% | 2 407 | 3% |
| **Total** | 2 452 | 349 | 14% | 231 | 15% | 8 656 | 4% |

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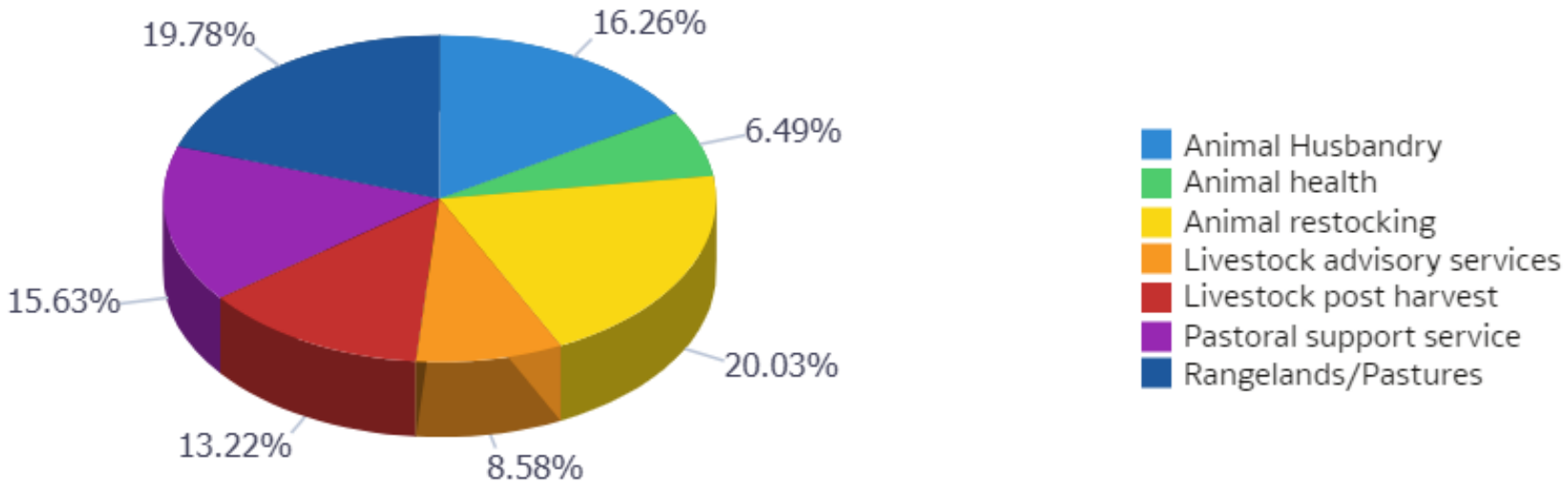
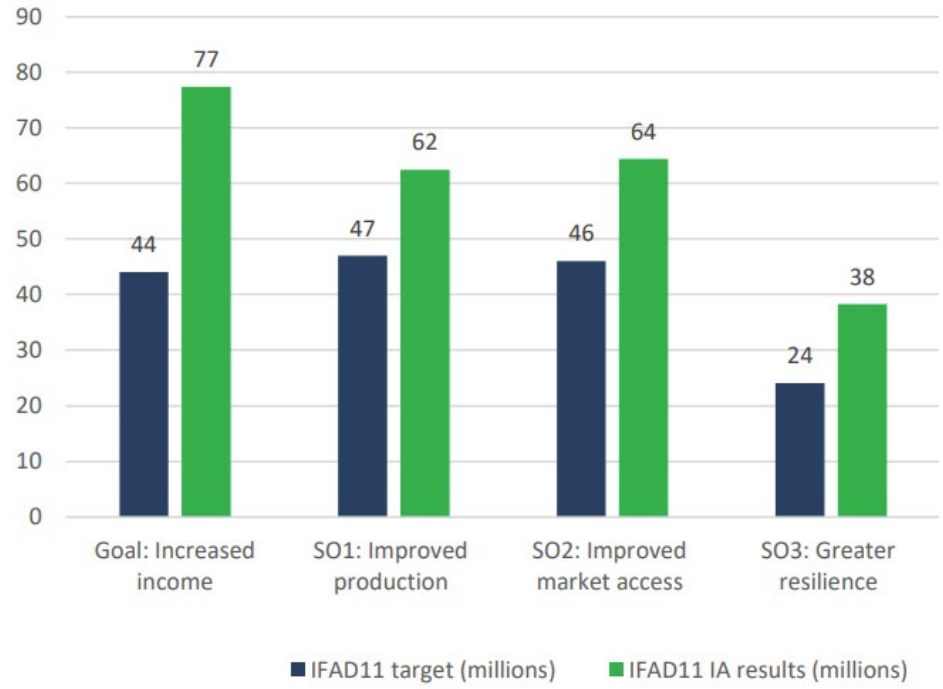
# Investments of the ongoing IFAD portfolio per area of livestock development




*IFAD improves access to inputs and to markets for poorest farmers and pastoralists*

# Impact assessment 2019-2021:
# 96 projects, total US$7.1 billion, reached 112 M people




Income gains were particularly large in countries with livestock projects

Higher market access increases in Kyrgyzstan, Pakistan and Tunisia, which were all livestock projects

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https://www.ifad.org/ifad-impact-assessment-report-2021/index.html

# Conclusions for sustainable food and feed systems

- Eradicate hunger and nutrient deficiency requires reducing FLW, improving productivity in LMIC, better access to markets for small producers…
- This needs to happen within strict environmental boundaries, including climate change, biodiversity and land
- Better circularity can reduce food-feed competition
- Single metrics need to be overcome
- Approaches like agroecology can help avoid tradeoffs between environment, economic and social dimensions of sustainability
- We need to invest in small-scale livestock for more sustainable food systems

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**Contact**

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# Thank You

Acknowledgments to Félix Teillard (FAO)

27 August 2023

# Livestock platforms and networks (transformation levers)

**NGOs & CSOs**
- World Farmer Organization
- WAMIP (pastoralists)
- WWP

**Other platforms**
- GRSB (sust. beef)

**Regional FAO commissions**
- CODEGALAC (Latin America)
- APHCA (Asia and Pacific)

**Private sector organizations**
- Milk: IDF, GDP
- Meat: IMS
- Poultry: IPC
- Feed: IFIF

**Research networks**
- Global Research Alliance on Agricultural GHG (GRA)
- LD4D (Livestock Data)

**Knowledge management**
- Pastoral systems knowledge hub
- Agroecology knowledge hub
- Global Soil Partnership

**Multistakeholder platforms (secretariat FAO)**
- Global Agenda for Sustainable Livestock (GASL)
- Livestock Environmental Assessment and Performance partnership (LEAP)
- Committee on Food Security recommendations (2016)

**Intergovernmental bodies**
- CILSS Sahel
- FAO COAG Sub-Committee on Livestock
- FAO Intergovernmental Working Group on Animal Genetic Resources

**IFIs**
- World Bank
- IFAD
- IFC
- EBRD
- RDBs

IFAD | FIDA