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Topic: Feeding Animals or Feeding People: Land Use Trade-offs in Global Grain Production

Introduction

Global grain production shapes how land is used in food systems and research shows that land is already under immense pressure from agricultural expansion (Winkler et al., 2021). Crops such as maize, soy, and wheat occupy large areas of arable land, yet a substantial share is used as livestock feed rather than direct human consumption. This creates a clear trade-off in land allocation between feeding people and supporting food production (Manzano et al., 2025).

Converting land for crop production remains a leading cause of deforestation, habitat loss, and biodiversity decline, while intensification through fertilizers and monoculture systems places additional strain on soils and water systems. Large-scale analyses show that animal-based production requires more land and generates higher environmental impacts than plant-based alternatives (Poore & Nemecek, 2018). A significant share of agricultural land is therefore used in ways that increase ecosystem pressure without directly increasing food availability. These pressures are not solely driven by dietary patterns, but also by population growth, rising incomes, global trade systems, and agricultural policies that support intensive livestock production, shaping how land is allocated globally. Market demand, profitability of livestock systems, and global trade structures favor feed production at scale, often reinforcing land exploitation and overuse.

This study examines how grain is allocated between human consumption and livestock feed and evaluates the extent to which current allocation patterns drive land use inefficiency and ecosystem pressure. It aims to show how redirecting grains towards direct human consumption could reduce environmental strain while sustaining food production.

Global agricultural land use reflects a persistent trade-off between feeding people directly and producing feed for livestock. Approximately 1.6 billion hectares of land are used for agriculture worldwide, with 50% of cropland dedicated to grain production (FAO, 2025). However, a significant proportion of this grain production is not used for direct human consumption. Only about 48% of global cereal production is consumed directly by humans, while 41% is used for livestock feed and 11% for biofuels (Ritchie, 2021). When pasture and feed cropland are combined, around 80% of global agricultural land is used for meat and dairy production (Poore & Nemecek, 2018).

These patterns of grain allocation generate measurable inefficiencies in food production and place increasing pressure on land systems, with consequences that can be observed across food system efficiency, ecological impact, and the economic structures that sustain current production pathways. These global allocation patterns create both ecological and food system pressures.

How Grain Allocation Creates Pressure on Land Systems

The current allocation of grain creates a structural inefficiency in the global food system. Although grains are converted into animal products, the process results in significant losses of energy and nutrients, reducing the total calories and protein available for human consumption (Ritchie, 2021). Around 36% of global crop calories are used as animal feed, yet only 12% are converted into food consumed by humans (Cassidy et al., 2013).

This inefficiency creates direct environmental consequences across land systems including:

- Greenhouse gas emissions and excessive water use
- Habitat degradation and biodiversity loss driven by cropland expansion into forests and natural ecosystems
- Disproportionate land use demands for animal-based protein, which require up to 50 to 100 times more land per gram of protein compared to plant-based sources (Ritchie, 2022).

This pressure is reflected in land use distribution patterns, where cropland accounts for approximately 46% of land use in studied systems, compared to 21% for forests and 16% for grasslands, highlighting the scale at which agricultural expansion is displacing natural ecosystems (Liu et al., 2025).

From an economic perspective, this system steers land use towards production pathways that priorities profitability and rising demand for livestock products, often at the expense of efficiency in feeding populations. It also creates global dependencies, where land in one region is used to sustain consumption patterns in another region, with environmental costs that are not fully accounted for (Searchinger et al., 2019). This pattern of dependency also reflects the political economic relationships between high income and lower income countries. As the global population continues to grow, reaching approximately 8.2 billion, this inefficiency becomes more critical (United Nations, 2024). If crops were redirected toward direct human consumption, global food availability could increase by up to 70%, potentially feeding an additional 4 billion people (Cassidy et al.,
2013). Beyond production, land as an ecosystem is directly impacted by these allocation patterns. Intensive grain cultivation for feed drives soil degradation, reduces biodiversity, and disrupts ecosystem functions such as carbon storage and water regulation. Over time, this weakens the resilience of land systems and reduces their capacity to sustain both ecological integrity and longterm agricultural productivity.

Research shows that plant-based/alternative protein sources on average require both less land and generate less environmental impact than conventional animal products (Malila et al., 2024). This approach targets the structural drivers of inefficient allocation by shifting the incentives. This is done by reducing demand for land-intensive production and by improving overall efficiency in production. The solutions do, however, face limitations. There is also a limitation when it comes to alternative protein. It faces barriers that are related to technological development, cost, and consumer interest. The challenges directly highlight that the structural changes are relevant and necessary, for the implementation to have any real meaningful effect. The transition might also have a dual effect, where consumers and ecosystems benefit from both increased efficiency and reduced environmental pressure. Producers in the livestock sector might face economic losses. Increased efficiency in food systems has the potential to improve global food availability. Which has the potential of benefiting lower-income populations, yet the distribution and access of these gains remain challenges.

Drivers of the Problem

Dietary patterns have shifted significantly with economic development and changing lifestyles. Global preference for products from animals continues to rise, with meat consumption increasing from 23 kg per capita in 1961 to 43 kg in 2021 (Ritchie, 2023). At the same time, global population growth amplifies total demand. Income levels also shape consumption patterns, with higher income countries consuming significantly more meat per capita than lower income countries (Ritchie, 2023). Agricultural subsidies and export driven production systems also reinforce this structure by financially supporting intensive livestock and feed crop industries in many countries. At the same time, population growth and urbanization continue increasing overall food demand, placing additional pressure on agricultural lands. This creates a system where rising incomes drive demand for livestock products, reinforcing the prioritization of feed crop production.

Global trade further strengthens this structure. The meat industry, valued at over $2 trillion, shapes agricultural priorities and land use decisions at scale (IDTechEx, 2020). Countries with strong agricultural sectors specialize in producing feed crops for export, embedding grain production within global supply chains that priorities efficiency and profit over sustainability. Consumer behavior also reinforces this system. Although plant based meat alternatives have improved significantly, many consumers still prefer conventional meat products due to factors such as taste, texture, and appearance (Szenderák et al., 2022). This continued preference sustains demand for livestock production and the large scale feed crop systems that support it. Consumer preferences also reinforce this system. Although plant based meat alternatives have improved significantly, they are still not preferred over conventional meat products in many contexts (Szenderák et al., 2022).

Reducing Pressure on Land Systems

Addressing these pressures on global land systems requires changes across both food production and consumption systems. Shifting dietary patterns offers one of the most effective ways to reduce this pressure. Evidence shows that adopting predominantly plant-based diets could reduce agricultural land use from approximately 4.1 billion hectares to around 1 billion hectares (Ritchie, 2023). Reducing meat consumption and increasing the share of plant-based foods would free up large areas of land, lower environmental

impacts, and improve efficiency in food production. This shift would also strengthen food security by increasing the proportion of crops used directly for human consumption.

Targeted policy interventions, changes in consumption behavior, and restructuring of agricultural incentives are necessary to support this transition. Aligning economic systems with sustainable land use goals will go a long way in ensuring that food production systems meet future demand without exceeding ecological limits of the land it is produced on. One important approach is reforming agricultural subsidies that currently incentivize emission intensive and land-demanding livestock production. (Springmann & Freund, 2022) shows that restructuring subsidies to more sustainable food production has the potential to improve both environmental and health outcomes, as well as maintain economic benefits.
(Read et al., 2022) investigates food system interventions, such as waste reduction. Can decrease land-use pressure and biodiversity loss significantly. The paper shows that a significant section of agricultural land Is indirectly used for livestock food, not direct human consumption. Including crops grown, that are used as animal feed and land used for pasture/grazing.

Conclusion

The current allocation of grain reflects a system that prioritizes livestock production at the expense of efficiency in feeding populations and the sustainability of land systems. This imbalance continues to drive habitat loss, biodiversity decline, and the degradation of ecosystems that are central to SDG 15 on Life on Land. These pressures are reinforced not only by rising meat consumption, but also by broader economic and structural systems that shape global food production. Addressing this requires a shift in how grain is used, supported by changes in consumption patterns, policy direction, and economic incentives that reduce pressure on land. Aligning food systems with the goals of SDG 15 will be critical to ensuring that land is used in ways that can sustain both biodiversity and long-term food production.

AI STATEMENT

We used AI to source for relevant literature and to crosscheck the formatting of some of the references we inputed without Zotero. We also used Microsoft Word imbedded Grammarly to correct typos as we drafted our paper.

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