

Cage-Free x Climate

The case for compatibility



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Part A: Framing and Shared Findings

Executive Summary

Emissions, animal welfare, and cage-free practices and commitments increasingly feature in the sustainability disclosure frameworks shaping the agri-food industry.

The central question this series addresses is whether cage-free housing systems for broilers, laying hens, and gestating sows are compatible with climate action. The answer in every case is the same: compatibility is achievable, costs are manageable, and management of key system inputs determines the outcome rather than the housing system itself. For each of the three industries, the series offers a specific recommendation for transition to climate-efficient cage-free systems.

The shared finding.

For broilers, layers, and sows alike, feed production is the dominant source of greenhouse gas emissions. That share rises further for Asian producers reliant on imported, carbon-intensive feed grains. The primary source of welfare–climate tension is the same in all cases: cage-free systems give animals more space and freedom of movement, which raises energy expenditure slightly and, in some configurations, the amount of feed required per unit of output. This is a genuine trade-off but in every case the series identifies management levers that contain or reverse it.

The cross-cutting levers.

Four management levers consistently have far greater impact on emissions than higher-welfare housing — and the first of them matters far more than the rest. **Feed sourcing is the single largest determinant of climate outcomes in all three cases.** Feed production accounts for roughly 60–84% of total emissions, so avoiding high-deforestation supply chains and reducing soy dependence delivers climate gains that dwarf any difference between housing systems.

The practical implication is that a producer moving to higher-welfare farming while avoiding deforestation-linked feed can improve welfare and cut emissions at the same time.

- **Manure and litter management** — through moisture control, short-storage handling, and downstream abatement — reduce

Recommended Pathways for New Investment

The climate-compatible higher-welfare configuration for each species, and its enabling conditions

Gestating Sows	Broilers	Laying Hens
RECOMMENDED SYSTEM Full group housing — electronic sow feeders (ESF) or free-access stalls, with precision feeding	RECOMMENDED SYSTEM Cage-free floor system, moderately slower-growing (BCC) genetics at reduced stocking density	RECOMMENDED SYSTEM Cage-free — barn or aviary (co-equal; choose on management capability & local conditions)
Enabling conditions • Precision feeding cuts N/P excretion & feed GHG • Stable grouping + parity-matching + adequate space • Short-storage manure handling; composting / biochar	Enabling conditions • Low- or no-deforestation feed sourcing • Environmental enrichment + appropriate lighting • Housing-energy mitigation (e.g. heat exchange) • Captures most welfare gain at moderate climate cost	Enabling conditions • Deforestation-free feed / lower-impact protein • Manure & litter management (low-CP diet, belt, moisture) • Mortality control: rearing, aviary design, stockmanship • Enriched cage is a transitional step, not the destination

Source: ARE synthesis of cited LCA and welfare literature.

greenhouse gas and ammonia emissions regardless of which housing system is operated.

- **Reproductive and production performance** — through stable grouping, appropriate genetics, and active management of mortality and culling — is where cage-free systems earn their climate offset.
- **Housing-energy design** — ventilation, heating, and cooling — determines whether the infrastructure of higher-welfare housing adds to or contains the energy footprint.

Recommendations

Each part of the report sets out a full recommendation:

Gestating sows: full group housing with electronic sow feeders (ESF). ESF feeds each sow to her own requirement and lowers dietary crude protein and soy inclusion. That cuts nitrogen excretion by up to 17% and phosphorus by up to 15%, which reduces the ammonia and nitrous oxide arising from manure, while optimised precision feeding can cut system-wide emissions by up to 6%. Because feed is the largest source of emissions in pig production — between 70% and 77% in import-reliant Asian systems — precision feeding is an integrated component of group sow housing.

Broilers: cage-free floor systems, moderately slower-growing birds at reduced stocking density, with enrichment and a suitable lighting regime. Slower-growing breeds at lower density are not the highest-welfare option available but they capture most of the welfare gain at a moderate climate cost. They also reduce antibiotic use, mortality and leg problems, and help with food safety in hot climates. Feed sourcing affects the climate result more than housing choice.

“This series addresses the common assumption that higher-welfare systems are a luxury the industry cannot afford and finds it substantially overstated.”

Laying hens: cage-free, barn-raised single or multitier (aviary).

Both enable hens to exhibit the behaviours on which the welfare case rests: nesting, perching, dustbathing, foraging, and free movement. The conventional cage provides none of those and the enriched cage only offers partial benefits. Single-tier systems carry less keel-fracture risk and are simpler to run. Aviaries allow the fullest range of behaviour and hold more birds per square metre of floor. Producers should choose between them on the basis of their own management capability, local conditions, expected demand, and economics.

Introduction

The global livestock sector faces two conflicting pressures.

1. A growing body of scientific evidence, civil society advocacy, investor scrutiny, and regulatory momentum calling for better farm-animal conditions: more space, more behavioural freedom, and an end to the most restrictive confinement systems.

2. The urgent need to reduce food-system contributions to greenhouse gas emissions, which account for roughly one-third of global anthropogenic emissions (of which animal-based foods comprise more than half).

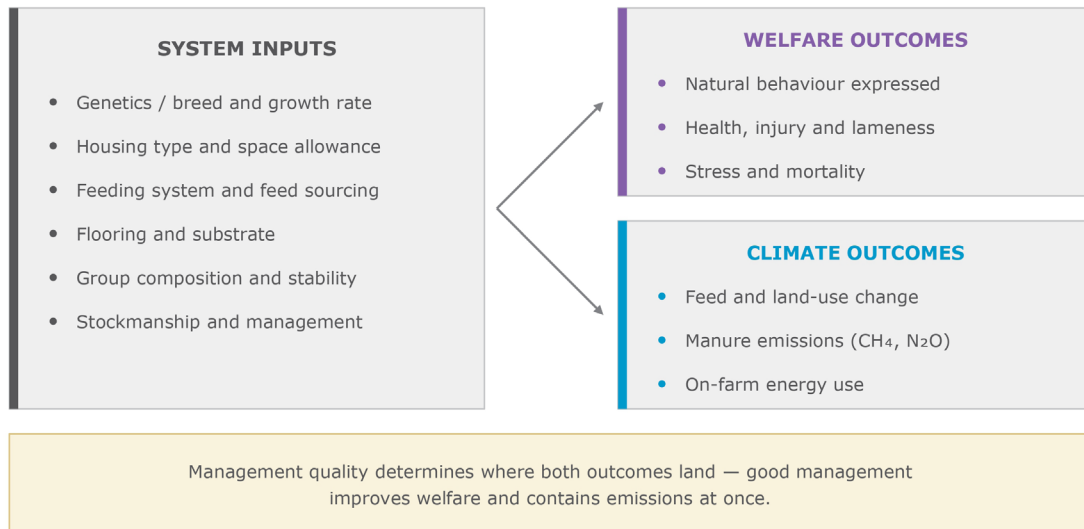
Where these two pressures meet, producers, investors, and policymakers face a question: can higher-welfare production align with climate goals?

The common assumption is that it cannot. The argument goes that higher-welfare systems use more space, more feed, more energy, and more infrastructure per unit of output and that adding these costs is a luxury the industry cannot afford. This assumption functions as a brake on cage-free welfare transitions worldwide, but it's particularly obstructive in Asia. Not only does Asia produce the majority of the world's poultry and pork, but welfare regulation is limited and the evidence base drawn from temperate, high-regulation industries does not always transfer directly.

This series directly addresses that prevailing assumption and finds it substantially overstated. Across broilers, layers, and sows, scientific literature shows that the relationship between higher-welfare housing and climate performance is not a fixed trade-off. The welfare-climate conflict is real in some cases, absent in others, and manageable across the range. What determines outcomes for producers is not primarily the housing system but the combination of management practices that

How Housing Shapes Welfare and Climate

The system inputs, and how they are managed, determine both welfare and climate outcomes — not the housing system alone.



Source: ARE analysis.

accompany the housing change: how feed is sourced and formulated, how manure is handled, how groups are composed and stabilised, and how reproductive and production performance are maintained through the transition.

The series is organised around that finding. Each of the three parts is structured identically, analysing the key welfare determinants and climate drivers for that farmed animal before bringing them together in an input-by-input assessment of where welfare and climate align, conflict, or move together conditionally. This analytical structure allows the welfare–climate relationship to be characterised precisely, at the level of decisions producers and investors actually make, rather than as a single aggregate housing-system choice. The evidence is presented as it stands, including genuine conflicts and evidence gaps.

Compatibility is achievable and the series is intended to be useful to companies, especially producers, who need to understand what that achievement actually requires.

The series is addressed primarily to producers, retailers, and investors operating in or engaging with Asian livestock markets, though the evidence base and framework apply more broadly. The Asian context receives specific attention in each part: the geographic transferability of evidence from temperate industries, the production conditions that differ materially from European and North American baselines, and the commercial and regulatory landscape that shapes the pace and form of welfare (cage-free) transitions in the region.

Parts B1 to B3 cover gestating sows, broiler chickens raised for meat, and laying hens. Each can be read independently. Together they make a case that the welfare and climate transitions facing livestock production are not diverging agendas. Where the evidence is followed carefully and management is designed accordingly, they are on the same pathway towards a sustainable and just transition.

Cross-Cutting Methodological Notes

The three parts are based on detailed analytical literature reviews, each ending with animal-specific methodological caveats. Four issues, however, apply across all cases and are summarised here to avoid repetition. Readers should treat them as applicable throughout; animal-specific details address only issues particular to broilers, layers, and sows.

Reading the comparative figures. The comparative Life Cycle Assessment (LCA) figures in each chapter depend on a small set of methodological choices. These choices have been flagged to help producers and investors interpret the evidence accurately and apply it to their own context — especially in tropical and subtropical Asian markets, where evidence drawn largely from temperate, highly regulated industries may not transfer directly.

Functional unit and system boundary. The unit chosen to express results materially affects how systems perform, because systems with higher output or larger product size appear relatively better under some units than others. System boundaries matter as well; including or excluding upstream and downstream stages can change results, especially for systems with higher mortality or shorter productive lifespans, where a narrow scope can hide the replacement burden. Cross-study comparison therefore requires close attention to both choices.

Land-use-change accounting for soy. Soybean meal is the main protein source in commercial pig and poultry rations, and how its land-use-change (LUC) burden is accounted for can move a system's footprint several times over. Three choices matter: whether LUC is counted at all, whether indirect change is included alongside direct conversion, and the amortisation period applied. The stakes are large, since soy-related land-use change can account for more than half of total climate impact in some broiler studies. Comparative figures should therefore be checked to confirm both systems were assessed on the same basis.

Geographic transferability to Asian markets. The great majority of the high-quality LCAs and welfare studies cited in this series were conducted in the EU, the UK, North America, and Australia, and several of their findings are conditioned on temperate-climate, high-input, regulated production. Four shifts recur when that evidence is applied to tropical and subtropical Asia:

- **The heating-energy penalty largely disappears.** A substantial part of the higher-welfare environmental penalty in cold-climate studies comes from heating lower-density housing in cold weather. In tropical climates, this driver is minimal.
- **Heat stress becomes the dominant production risk instead.** The binding constraint shifts from heating to cooling and ventilation. Chronic heat stress reduces feed intake, fertility, growth, and product quality. This is most relevant in caged or high livestock mass/density systems.

“The clearest shared thread is feed, which dominates the climate footprint of all three systems, while heat stress is an ever-increasing climate impact and energy demand on caged systems.”

- **Feed and LUC profiles differ.** Proximity to high-LUC South American soy means a housing comparison calibrated on lower-LUC feed will understate the feed-driven GHG profile facing many Asian producers.
- **Management maturity is earlier.** Higher-welfare and explicitly cage-free management expertise across much of Asia is at an earlier stage — so results from mature industries represent a best case rather than the expected outcome during early adoption.

Overall Conclusion

The three farmed animals in this series do not give an identical answer to the welfare–climate question, and we have not forced one.

- **For gestating sows,** the move out of crates is close to a win-win, because group housing unlocks shared precision feeding that can more than offset the cost of extra feed.
- **For broilers,** a trade-off remains — moderately slower genetics and lower densities do raise the feed needed per unit of output — though it is a manageable one.
- **For laying hens,** the picture is closer to neutral, depending on how well the system is run.

In every case, the same set of inputs — feed, manure, the animals’ productivity, and the building’s energy — decides where the balance lands, far more than the choice of housing itself.

The clearest shared thread is feed, which dominates the climate footprint of all three systems. It is through feed that giving animals more space and freedom registers as a climate cost, by modestly raising the energy and feed needed per unit of output. The same feed that drives the added climate cost is also the most powerful means of offsetting it: sourcing lower-deforestation feed and reducing soy dependence delivers climate gains that dwarf any difference between housing systems. Meanwhile several of the most welfare-significant changes — enrichment and lighting for broilers, nests and perches for hens, the feeding system itself for sows — carry little or no climate cost at all.

The decisive variables sit upstream and downstream of the housing decision: feed sourcing, manure and litter handling, the reproductive and production performance that spreads a footprint across more output, and the energy design of the building.

This is why the recommended destinations differ by industry but rest on the same handful of levers.

None of the investment pathways is recommended unconditionally. Each rests on similar terms: low-deforestation feed, sound manure handling, mortality and performance management, and appropriate housing-energy design. Across all three, the housing transition and the climate objective are better understood as a single design problem to be solved rather than as opposing goals to be traded off.

The series is deliberate about the limits of this claim. The direction of the welfare findings is robust, but the magnitude of both the welfare gains and the environmental penalties is uncertain and sensitive to local conditions. Most of the underlying evidence is temperate and the Asian evidence base in particular remains thin. These conclusions are best read as a sound basis for decisions that should be re-grounded in local transition-cost, productivity and emissions data as that evidence matures, not as precise predictions for any single market.

That caveat is also where the opportunity lies. Asia's poultry and pig capacity can be far easier to design as higher-welfare, climate-compatible systems from the outset than to retrofit later.

For the producers, buyers, banks, and investors shaping that build-out, the message of this series is simple: Higher welfare does not have to come at the expense of the climate. Systems that give animals materially better lives can also perform well on climate, as long as feed, manure, productivity, and energy are managed well.

About this series

Cage-free × Climate: The Case for Compatibility is published in four parts, with a shared annex of source tables. Each part is self-contained and can be read on its own; this document, Part A, sets out the shared framing, the methodology, and the conclusions the series draws together.

Part A: Framing and Shared Findings (this document)

The question the series addresses, the shared methodology and findings, and the recommended pathway for each category.

Part B1: Gestating Sow Housing Systems, Welfare, and Climate Impact

Group housing with electronic sow feeders improves sow welfare, and the shared precision feeding it enables offsets the climate cost of the extra feed.

Part B2: Broiler Growing Systems, Welfare, and Climate Impact

Moderately slower-growing birds at lower stocking density capture most of the welfare gain at a moderate climate cost, and feed sourcing matters more than the housing choice. Caged systems perpetuate the cost and impacts of heat stress.

Part B3: Layer Hen Housing Systems, Welfare, and Climate Impact

Barn and aviary systems restore the behaviours the welfare case rests on, usually at minor climate cost. That cost narrows where laying rate and feed efficiency are maintained, and better feed sourcing can outweigh it altogether.

Annex: Expanded Source Tables

The full evidence tables behind Parts B1–B3: every study cited, with year, type, geography, system, and welfare relevance. Shared across the series.

Endnotes

1 Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food*, 2(3), 198–209. <https://doi.org/10.1038/s43016-021-00225-9>

2 Xu, X., Sharma, P., Shu, S., Lin, T.-S., Ciais, P., Tubiello, F. N., Smith, P., Campbell, N., & Jain, A. K. (2021). Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods. *Nature Food*, 2(9), 724–732. <https://doi.org/10.1038/s43016-021-00358-x>

3 FAO. (2026). FAOSTAT: Crops and livestock products [Data set]. Food and Agriculture Organization of the United Nations. <https://www.fao.org/faostat/en/#data/QCL>

4 World Animal Protection. (2020). Animal Protection Index. <https://api.worldanimalprotection.org/>

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