# A SUSTAINABLE PATH

## REDUCING CARBON EMISSION IN AGRICULTURE

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*Issue tree theme

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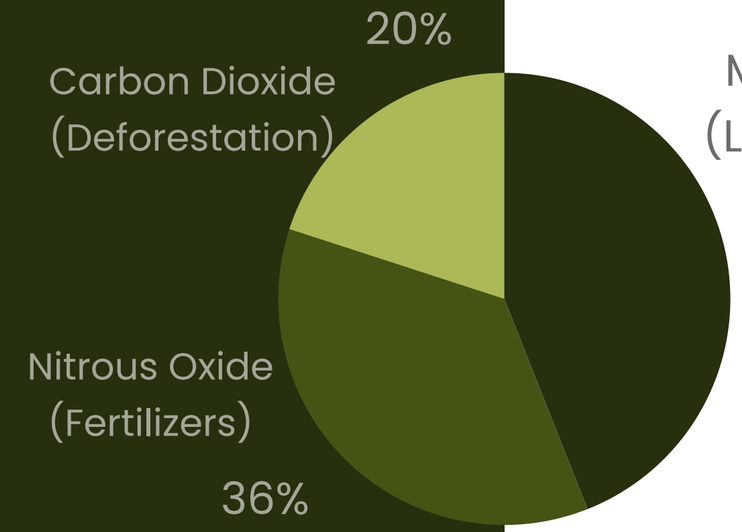
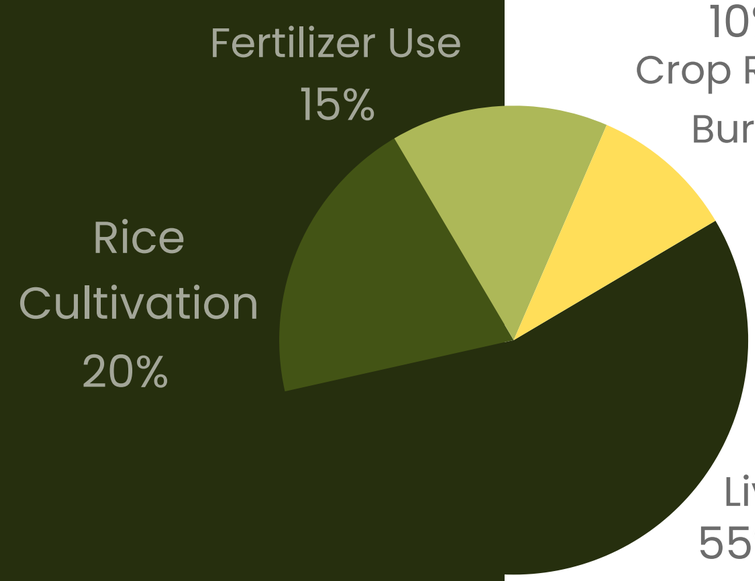
# CHOOSING AGRICULTURE DATA-DRIVEN INSIGHTS




Global Agriculture Emissions Breakdown




India's Agriculture Emission Sources

## Importance of Agriculture in Carbon Emissions

### Global Impact:

- Agriculture is the source of about **19-29%** of all greenhouse gas (GHG) emissions, and hence has a significant role to play in emission reduction activities.
- The major sources of GHG emissions were **methane** from livestock, about **44%** of agriculture's emissions, nitrous oxide from fertilizers, and about **36%**, and carbon dioxide from deforestation and land-use change.

### India's Perspective:

- Agriculture contributes around **18%** of the total GHG emissions of India.
- Agricultural activities like rice cultivation, cattle rearing, and fertilizer application account for more than **70%** of India's agricultural emissions.
- India being the largest food producer in the world and being the **single largest producer** of rice and wheat, **optimizing supply chains** with agriculture can bring huge global and local environmental benefits.

# CHOOSING AGRICULTURE DATA-DRIVEN INSIGHTS

## Comparison with Healthcare and E-commerce

| Criteria | Agriculture | Healthcare | Quick/ E-commerce |
|---|---|---|---|
| **Emission Contribution** | High (19-29% globally) | Moderate (~5% of global emissions) | Significant (10-15% of logistics-related emissions) |
| **Carbon Emission Sources** | Fertilizers, livestock, deforestation | Medical waste, equipment production, transportation | Logistics, packaging, delivery, energy use in warehouses |
| **Potential for Reduction** | High (alternative fertilizers, renewable energy, logistics) | Moderate (green procurement, energy efficiency) | High (last-mile delivery optimization, packaging reduction) |
| **India's Sectoral Impact** | Significant (18% of total emissions) | Relatively low (~7% of India's emissions) | Growing impact due to e-commerce boom |

**Why Agriculture?**

- High potential for emission reduction through improved farming practices, energy-efficient logistics, and carbon sequestration methods.
- It directly impacts food security, which is crucial for India’s socio-economic stability.
- The carbon footprint in agriculture is more widespread and varied, offering numerous opportunities for targeted interventions across the supply chain.

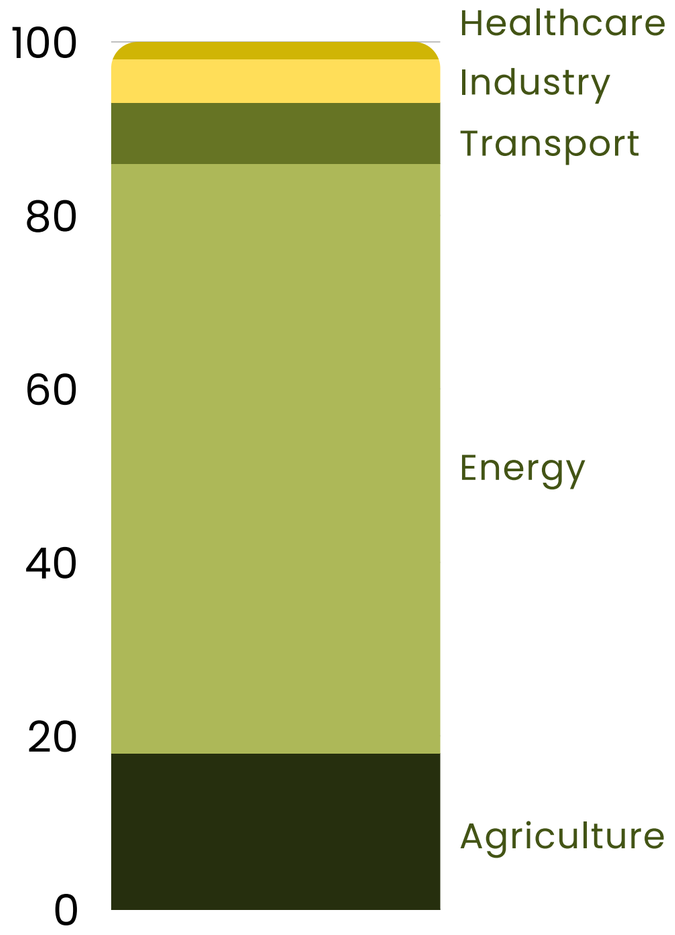
# CHOOSING AGRICULTURE DATA-DRIVEN INSIGHTS

Potential Emission Reduction Strategies for Agriculture

**STAGES**

- **INPUT**
  - Improved Seed Varieties → Reduced Fertilizer Use
- **PRODUCTION**
  - Precision Farming → Decreased Water Usage
- **LOGISTICS**
  - Renewable Energy in Cold Storage → Reduced Fuel Use
- **POST-HARVEST**
  - Efficient Packaging → Reduced Waste

## Comparison of Emissions Across Sectors (India)



# INDIA'S AGRICULTURAL EMISSION

## Rice Cultivation (20%)

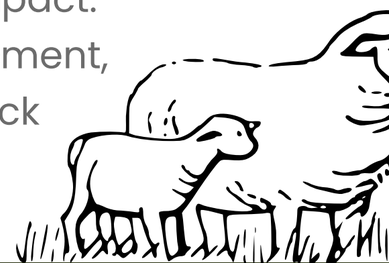
Rice cultivation contributes to methane emissions, particularly from flooded paddy fields. To reduce emissions:

- **Alternate Wetting and Drying (AWD):** This technique intermittently dries the rice fields, reducing methane emissions by limiting the anaerobic conditions that cause methane production.
- **System of Rice Intensification (SRI):** This method involves planting fewer seeds and using less water, which improves productivity while cutting emissions from flooding.
- **Use of Methane-Inhibiting Fertilizers:** Applying fertilizers with nitrification inhibitors can reduce methane emissions from paddy fields.
- **Direct Seeded Rice (DSR):** DSR involves sowing seeds directly into the field without puddling (wet preparation), which helps avoid continuous flooding and methane emissions

## Livestock Emissions (55%)

Livestock is responsible for methane emissions through enteric fermentation and manure management.
To reduce methane emissions from livestock:

- **Dietary Supplements:** Adding seaweed or nitrate-based additives to cattle feed can lower methane production during digestion.
- **Improved Manure Management:** Using anaerobic digestion converts manure into biogas, reducing methane emissions and generating renewable energy.
- **Breeding for Efficiency:** Selecting livestock with better feed efficiency (10-15% improvement) can significantly cut methane emissions per unit of milk or meat produced.
- **Precision Breeding**: Cross-breeding for nutrient-efficient animals further minimizes environmental impact.
- **Rotational Grazing:** Enhances land management, sequesters carbon in soil, and offsets livestock emissions.



# INDIA'S AGRICULTURAL EMISSION

## Fertilizer Use (15%)

Synthetic fertilizers contribute to nitrous oxide emissions, a potent greenhouse gas. Practices to reduce these emissions include:

- **Precision Agriculture:** Using data and technology (e.g., soil sensors, satellite monitoring) to apply fertilizers in precise amounts only where needed can minimize overuse and waste.
- **Organic Fertilizers and Biofertilizers:** Substituting chemical fertilizers with organic options, like compost or manure, can reduce nitrous oxide emissions.
- **Integrated Nutrient Management (INM):** This approach combines organic and inorganic fertilizers, using them in balanced quantities to reduce emissions while maintaining soil health.
- **Slow-Release Fertilizers:** Using fertilizers that release nutrients gradually can reduce nitrous oxide emissions by limiting the amount of nitrogen available for microbial conversion to gases

## Crop Residue Burning (10%)

The burning of crop residues (like straw from rice and wheat) releases $CO_2$, methane, and particulate matter into the atmosphere. Alternatives to burning include:

- **Incorporating Crop Residue into Soil:** Instead of burning, farmers can plow the residue back into the soil to improve its organic content and enhance soil fertility, reducing the need for chemical fertilizers.
- **Happy Seeder Technology:** This machine allows farmers to sow wheat directly into fields without burning the rice stubble from the previous harvest.
- **Biomass Conversion:** Crop residues can be converted into bioenergy or used in the production of biofuels and compost, providing a value-added solution to waste.
- **Adoption of Zero-Till Farming:** This method leaves crop residues on the field and sows new crops without tilling the soil, preventing emissions from residue burning while improving soil health

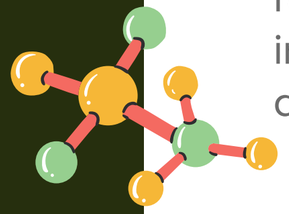
**Implementing these practices can significantly reduce India's agricultural emissions, helping to mitigate climate change while maintaining productivity.**

# GLOBAL AGRICULTURAL EMISSION

## Methane (Livestock) - 44%

Livestock methane emissions primarily come from enteric fermentation in ruminants (cows, sheep) and manure management. To reduce these emissions:

- **Feed Additives:** Incorporating feed additives such as seaweed, fats, and nitrate compounds can reduce the methane produced during digestion by altering fermentation processes in the rumen.
- **Improved Manure Management:** Techniques like anaerobic digestion of manure can convert methane into biogas, a renewable energy source, reducing direct methane release.
- **Genetic Selection:** Selective breeding of livestock for improved feed efficiency can reduce methane emissions per kilogram of meat or milk produced
- **Rotational Grazing and Agroforestry:** By integrating grazing management with trees or shrubs (agroforestry), methane can be offset by the carbon sequestered through plant growth, enhancing land use efficiency.



## Nitrous Oxide (Fertilizers) - 36%

Nitrous oxide ($N_2O$) is mainly emitted through the use of synthetic fertilizers and organic matter decomposition in soils. Reducing these emissions involves:

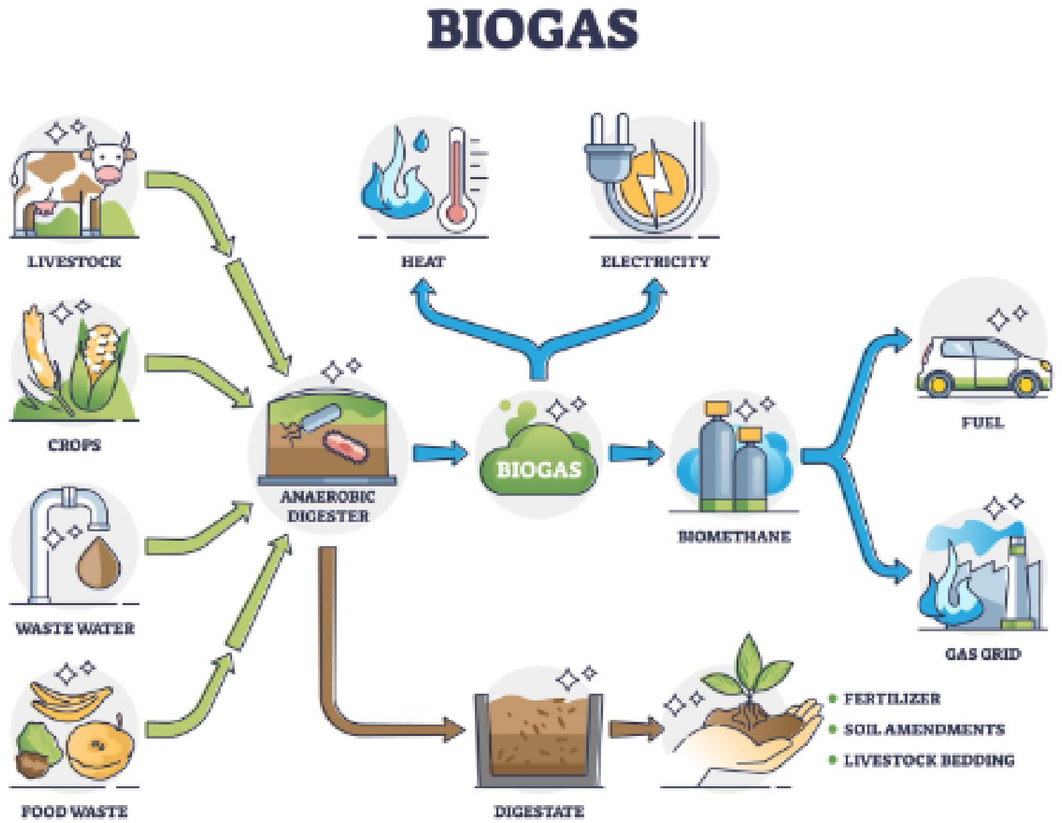
- **Precision Fertilization:** Precision agriculture techniques like variable-rate technology allow fertilizers to be applied only where and when needed, minimizing overapplication and reducing nitrous oxide emissions.
- **Organic Farming and Biofertilizers:** Replacing synthetic fertilizers with organic fertilizers (e.g., compost, manure) or biofertilizers like nitrogen-fixing bacteria can reduce $N_2O$ production by enhancing soil health and fertility naturally.
- **Nitrification Inhibitors:** Using chemical nitrification inhibitors reduces the conversion of ammonium to nitrate, thereby reducing nitrous oxide release from soils
- **Cover Crops and Crop Rotation:** Planting cover crops (e.g., legumes) that fix nitrogen naturally in the soil reduces the need for synthetic fertilizers, and crop rotation improves soil structure and fertility, lowering fertilizer demand.

# GLOBAL AGRICULTURAL EMISSION

## Carbon Dioxide (Deforestation) - 20%

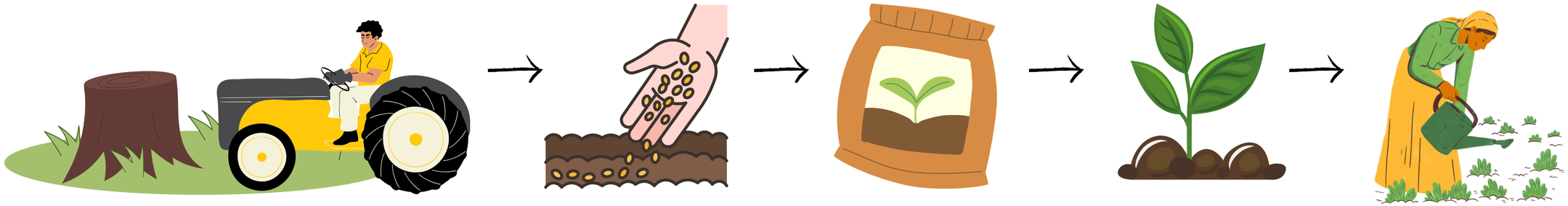
Deforestation for agricultural expansion is a significant source of carbon dioxide emissions. To curb these emissions:

- **Agroforestry:** Combining crops with trees or shrubs on farmland can both sequester carbon and provide farmers with additional sources of income (e.g., fruits, timber), reducing the need for further deforestation
- **Sustainable Land Use:** Zero-deforestation policies and sustainable land-use planning, including reforestation and afforestation, can prevent the conversion of forest lands into agricultural areas.
- **Regenerative Agriculture:** Practices like conservation tillage, permanent cover crops, and mulching help restore degraded soils, improve biodiversity, and sequester carbon while allowing continued agricultural productivity.
- **Rehabilitation of Degraded Land:** Instead of converting forests to farmland, restoring degraded lands for agriculture increases arable land area without further deforestation, while sequestering carbon in the process



# AGRICULTURE SUPPLY CHAIN: A MECE APPROACH

## 1.PRODUCTION



Land use
(deforestation,tillage)

Seed and fertilizer
procurement

Water and energy
use for irrigation

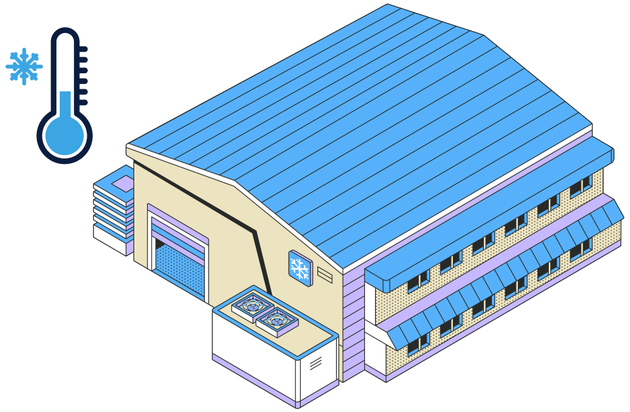
### Key Emission Sources

- **Fertilizer production**: $CO_2$ emissions (~1.5-3 tons $CO_2e$ per ton of fertilizer); **machinery operation** (~300-500 kg $CO_2e$/hectare annually).
- **Synthetic fertilizers**: $N_2O$ emissions (~2-6 kg $N_2O$/hectare annually); **irrigation** (~300 kg $CO_2e$/hectare).
- **Livestock**: Methane (~1.5-2.5 tons $CO_2e$ per head/year); **soil carbon loss** (~500-2,000 kg $CO_2e$/hectare annually from tillage); **deforestation** (~100-200 tons $CO_2e$/hectare).

# AGRICULTURE SUPPLY CHAIN: A MECE APPROACH

## 2.PROCESSING

Food processing and sorting



Cold Storage

## Key Emission Sources

- **Processing**: Energy use (~50-150 kg $CO_2e$/ton of food); **equipment electricity** (~20-50 kg $CO_2e$/ton).
- **Refrigeration**: $CO_2$ emissions (~1.5-2 tons/unit annually); **HFC leakage** (~1,300-4,000 kg $CO_2e$/ton).

# AGRICULTURE SUPPLY CHAIN: A MECE APPROACH

## 3.DISTRIBUTION

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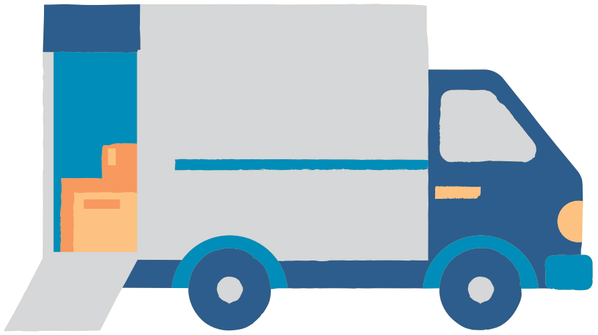

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Transportation of goods (farm to market)

Storage facilities

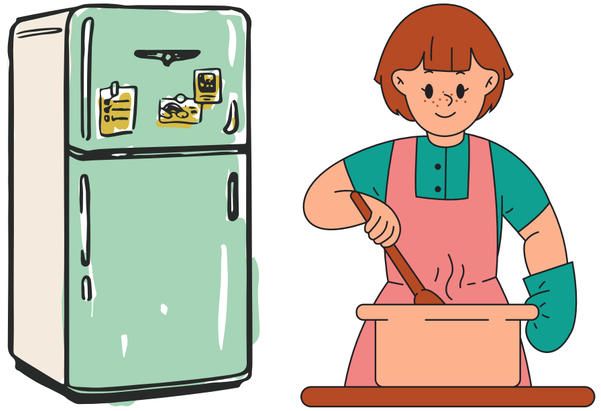
### Key Emission Sources

- **Transport**: $CO_2$ from road (~60-80 kg $CO_2$e/ton per 100 km) and **air freight** (~500 kg $CO_2$e/ton).
- Storage: **Refrigeration** (~1.5-2 tons $CO_2$e/unit annually); **HFC leakage** (~1,500-3,000 kg $CO_2$e/ton).

# AGRICULTURE SUPPLY CHAIN: A MECE APPROACH

## 4.RETAIL & CONSUMPTION


Retail operations (supermarkets, online)



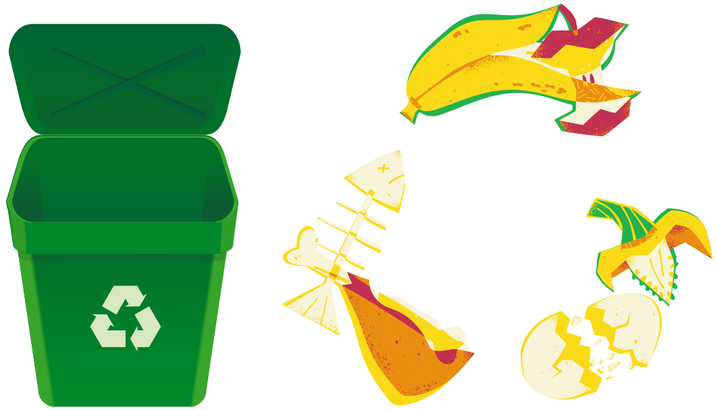
Consumer food storage & cooking

### Key Emission Sources

- **Retail**: Energy use (~200-300 kg $CO_2e/m^2$ annually for supermarkets); **packaging waste** (~200 kg $CO_2e$/ton).
- Consumer: **Household energy** (~500-1,000 kg $CO_2e$/year for **refrigeration** and cooking); packaging waste (~50 kg $CO_2e$/year).

# AGRICULTURE SUPPLY CHAIN: A MECE APPROACH

## 5.END-OF-LIFE



Food waste management

Agricultural by-products disposal

## Key Emission Sources

- **Food Waste**: Methane from **decomposition** (~1-1.5 tons $CO_2e$/ton in landfills); recycling emissions (~100-150 kg $CO_2e$/ton).
- **By-products**: Emissions from **crop residues** and **manure** (~200-500 kg $CO_2e$/hectare); methane from manure management (~1-1.5 tons $CO_2e$/ton).

# EMISSION HOTSPOTS

| Supply Chain Stage | Emission Hotspot | Real World Data |
|---|---|---|
| **Production** | Fertilizer Use(N2O)<br><br>Methane from livestock (enteric fermentation) | 14.5% of global GHG emissions from livestock<br><br>44% of agricultural emissions from methane |
| **Processing** | Energy used in processing | Cold storage accounts for 15% of global energy consumption |
| **Distribution** | Transportation fuel emissions | 10-12% of EU food system emissions are from transport |
| **Retail & Consumption** | Energy in retail & food waste | 8% of global GHG emissions from food waste |
| **End-of-Life** | Methane from food waste in landfills | Landfills account for 15.1% of US methane emissions |

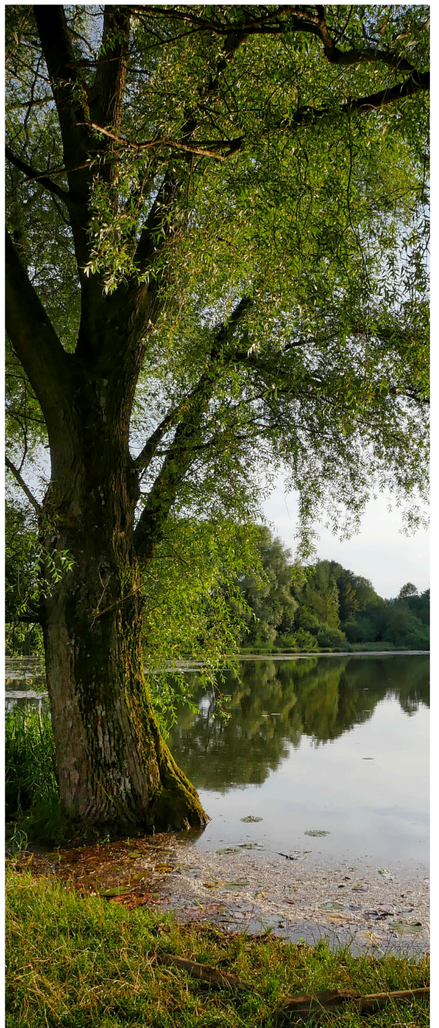
# NUMERICAL MECE ANALYSIS

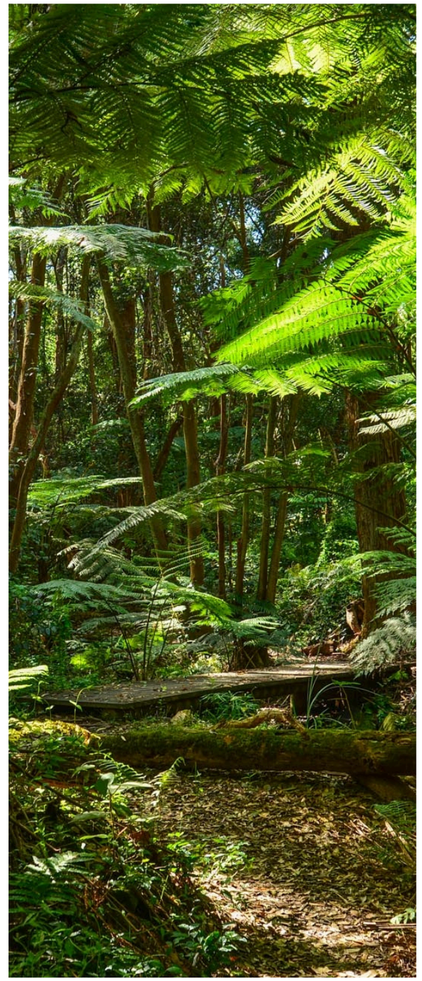
**Key Emission Sources Overview**

- Production Stage Total Emissions: Approximately 4.47 billion metric tons $CO_2e$.
- Processing Stage Total Emissions: Approximately 1.61 billion metric tons $CO_2e$.
- Distribution Stage Total Emissions: Approximately 1.80 billion metric tons $CO_2e$.
- Retail & Consumption Stage Total Emissions: Approximately 682 million metric tons $CO_2e$.
- End-of-Life Total Emissions: Approximately 180 million metric tons $CO_2e$.

**Key Insights from Numerical MECE Analysis**

- Total Estimated Emissions: Approximately 8.79 billion metric tons $CO_2e$ across the agriculture supply chain.
- Major Contributors:
  - Production Stage is the largest contributor (approximately 50.8%).
  - Processing and Distribution are significant, with potential for substantial reduction through efficiency improvements.
- Opportunities for Reduction:
  - Implementing precision agriculture to optimize inputs.
  - Enhancing waste management and recycling practices to mitigate food waste emissions.
  - Transitioning to renewable energy sources in processing and distribution.





# RISK ANALYSIS

| Supply Chain Stage | Strategy | Impact | Risk |
|---|---|---|---|
| **Production** | Precision agriculture, sustainable livestock management, and low-emission fertilizers | Reduced fertilizer and methane emissions. | High cost of technology. |
| **Processing** | Energy-efficient machinery and renewable energy integration. | Lower energy consumption and reduced emissions | High capital investment and energy reliability concerns |
| **Distribution** | Optimized logistics and electric vehicles for transportation | Lower $CO_2$ emissions from transport | Infrastructure limitations, especially in rural areas |
| **Retail and Consumption** | Energy-efficient retail systems, sustainable packaging | Reduced food waste and energy consumption | Consumer resistance & retailer investment challenge |
| **End-of-Life** | Composting, biogas production, and circular economy initiatives | Lower methane emissions from landfills | Infrastructure for waste management and effective waste segregation |


THANK YOU