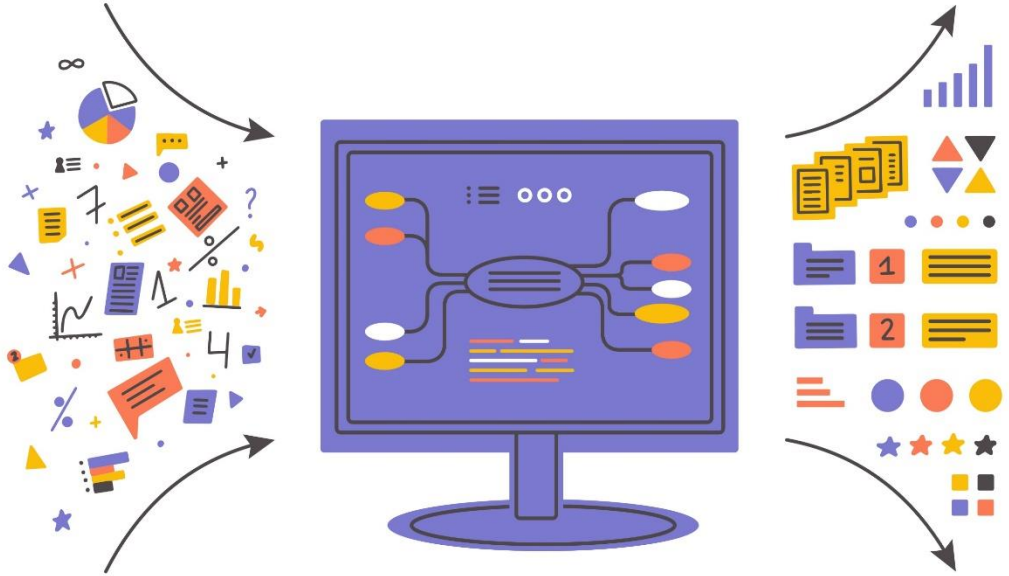
Goals, Strengths, and Limitations Governing the Use of Life Cycle Assessment in Food and Agriculture

CAST Commentary QTA2022-1
January 25, 2022



Celebrating 50 Years as the Trusted Source for Agricultural Science and Technology

CAST Overview

- 501(c)3 nonprofit organization
- Formed in 1972 as a result of a 1970 National Academy of Sciences Report
- Nonpartisan and apolitical
- Membership includes 27 scientific societies; 18 universities; 19 libraries; 45 nonprofits; 21 companies; and over 500 individuals from 46 states and 7 countries

Celebrating 50 Years as the Trusted Source for Agricultural Science and Technology

CAST Mission

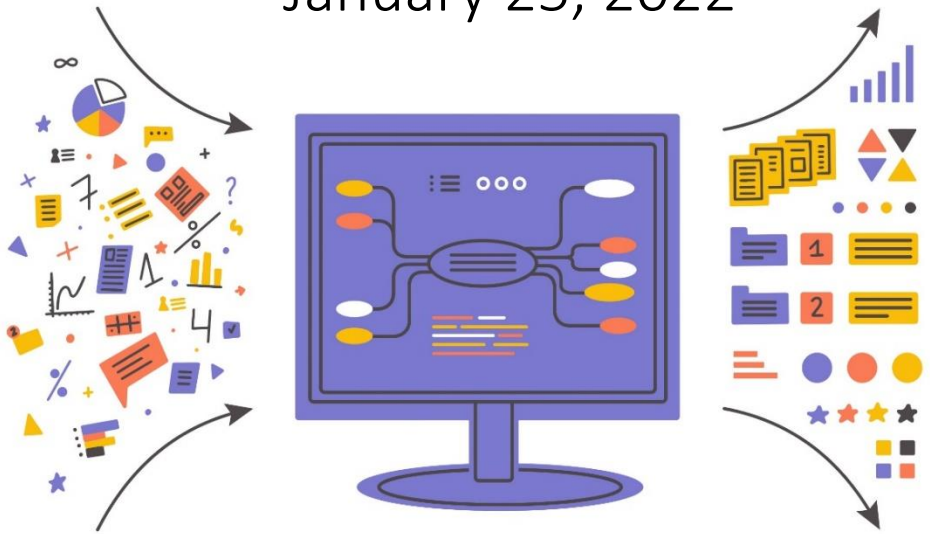
CAST convenes and coordinates networks of experts to assemble, interpret, and communicate credible, unbiased, science-based information to policymakers, the media, the private sector, and the public.

CAST Vision

A world where decision making related to agriculture, food, and natural resources is based on credible information developed through reason, science, and consensus building.

Goals, Strengths and Limitations Governing the Use of Life Cycle Assessment (LCA) in Food and Agriculture

CAST Commentary QTA2022-1
January 25, 2022



Presented by:

Marty Matlock, Ph.D.
University of Arkansas
Professor, Biological and Agricultural Engineering Department

Task Force Members

Task Force Chair

Marty Matlock
University of Arkansas

Authors

Stephen Pfister
ETH Zurich

Brad Ridoutt
CSIRO Agriculture and Food

Kurt Rosentrater
Iowa State University

Greg Thoma
University of Arkansas

Yuan Yao
Yale University

Reviewers

Tom Battagliese
BASF

Ermias Kebreab
University of California, Davis

Michael Wang
Argonne National Laboratory

CAST Liaison

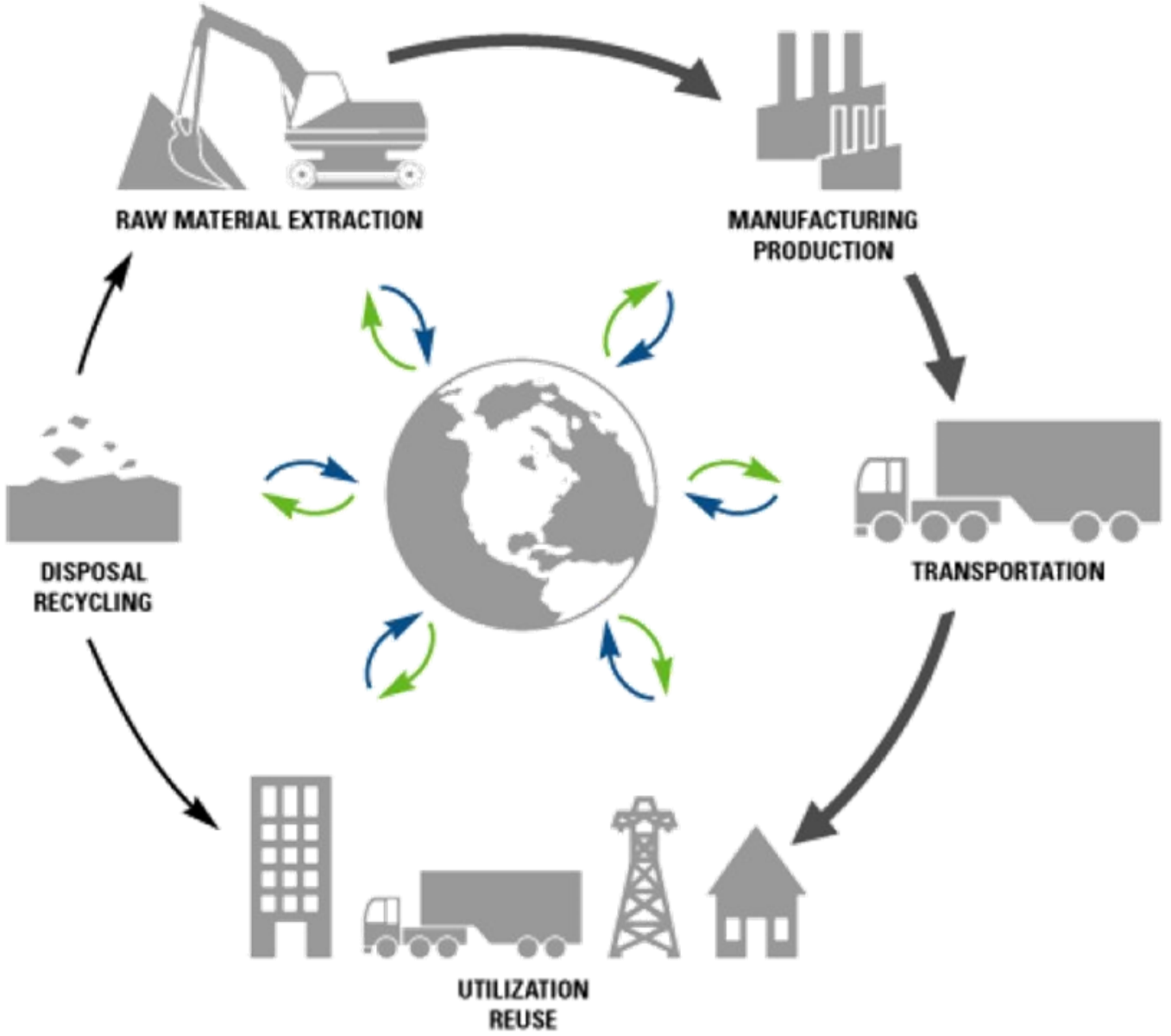
Juan Tricarico
Innovation Center for U.S. Dairy

What is LCA?

LCA is defined by the International Organization for Standardization (ISO 14040:2006) as…

- *The compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a products system throughout its life cycle.*
- *Life cycle is defined as consecutive and interlinked stages of a product system, from material acquisition or generation from natural resources to final disposal.*

What is LCA?


RAW MATERIAL EXTRACTION
MANUFACTURING
PRODUCTION
TRANSPORTATION
DISPOSAL
RECYCLING
UTILIZATION
REUSE

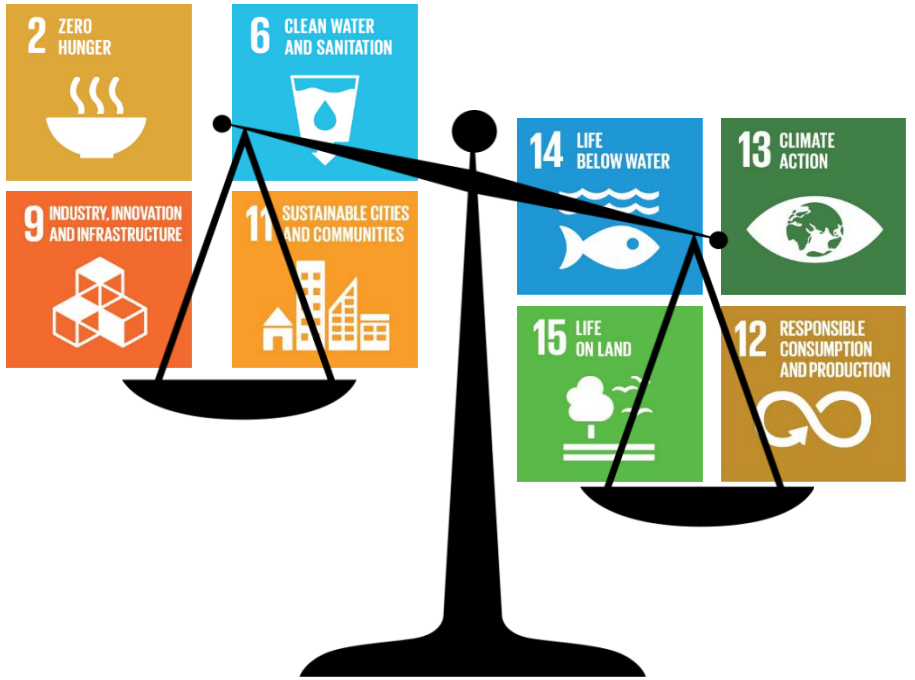
Why was LCA developed?

Increased awareness of the environmental impacts associated with production and consumption has resulted in the development of methods to better understand and address these impacts.

People make decisions, LCAs do not.

- Almost all decisions humans make have unintended consequences.
- Normative decisions, ethical framing, and risk value judgements are made by people in the context of laws, community norms, and social values.
- These are the most important decisions humans make.
- The outcome of an LCA cannot make this decision for you.
- LCAs do provide quantitative and risk-based assessments of outcomes of decisions.

SUSTAINABLE DEVELOPMENT GOALS



Celebrating 50 Years as the Trusted Source for Agricultural Science and Technology

50 1972 - 2022 CAST The Science Source for Food, Agricultural, and Environmental Issues

How is LCA used?

- To support broad environmental & sustainability assessments by your organization
- To establish baseline information for a product, process, or system
- To rank the relative contributions of individual steps or processes in the supply chain vis-à-vis environmental impacts
- To identify gaps in understanding or data
- To help guide product and process development to achieve environmental impact targets
- To provide information and direction to decision-makers / management

How is LCA used?

Two LCA approaches

Attributional

- Current/historic perspective of a product system
- Can assess minor changes in production or compare product systems
- Often requires allocation between products from multi-output systems

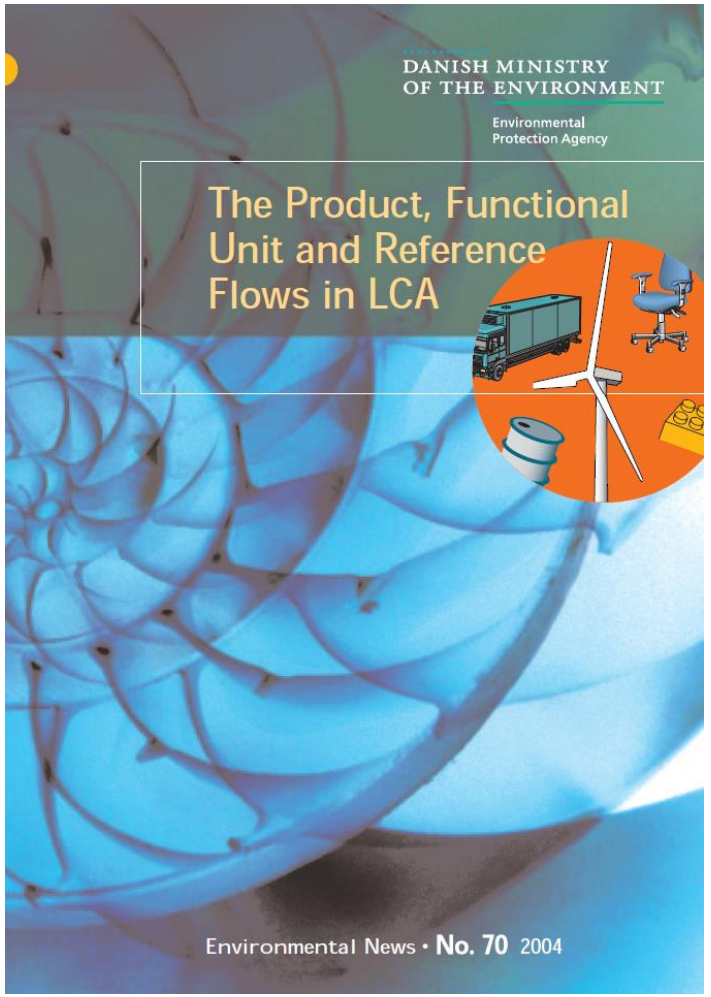
Consequential

- Forward-looking assessment
- Evaluates the potential environmental consequences of a decision, contrasted with the status quo
- Requires an economic understanding of marginal products in the market but avoid allocation

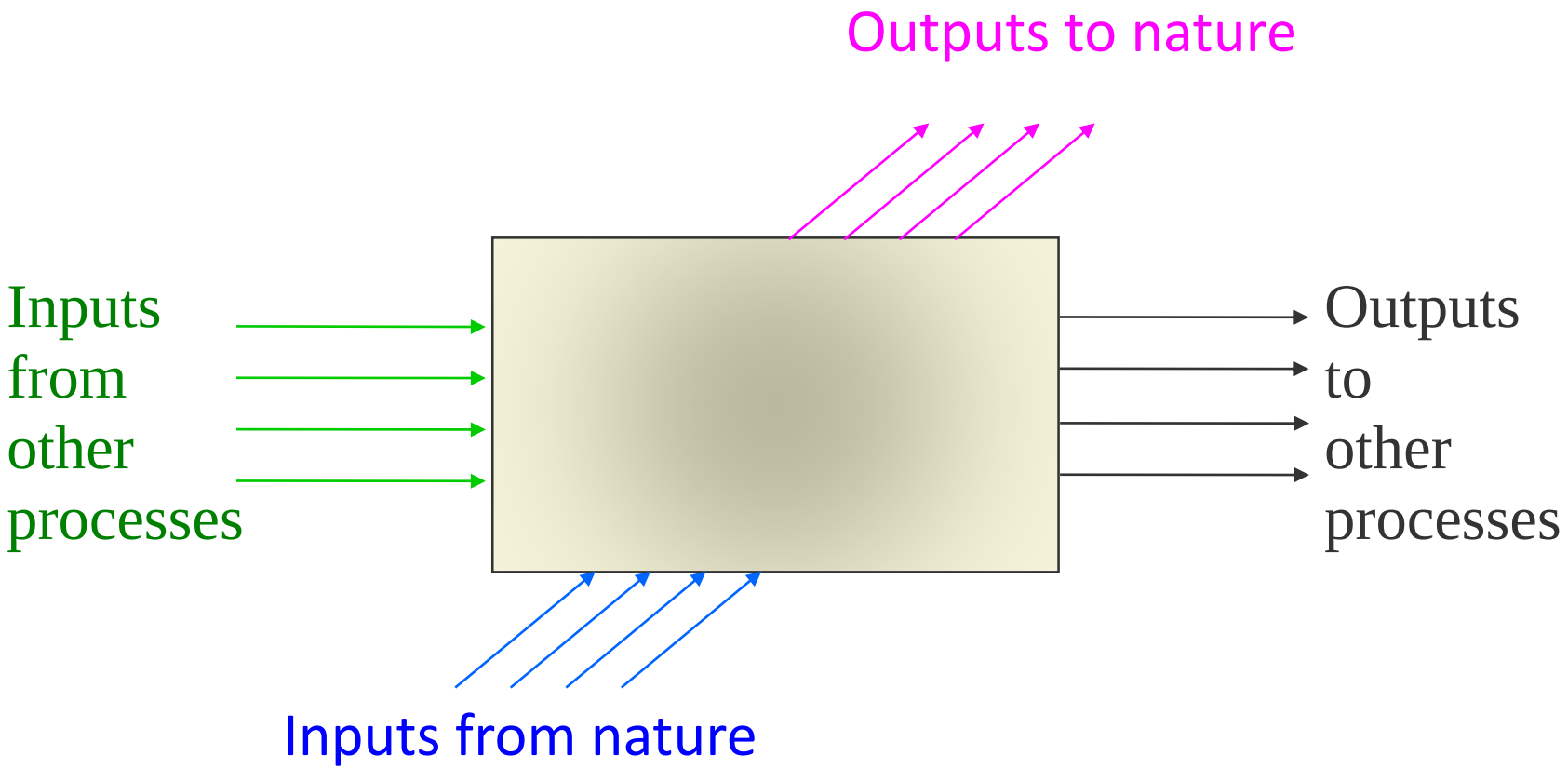
Reference Flows in LCA

- A *reference flow* is a quantified amount of product (parts, components, etc) necessary for the product to deliver the performance described by the functional unit.
- Reference flows translate the abstract functional unit into specific product flows for each of the compared systems, so that product alternatives are compared on an equivalent basis, reflecting the actual consequences of the potential product substitution.
- Reference flows are the starting points for building the necessary models of the product systems.

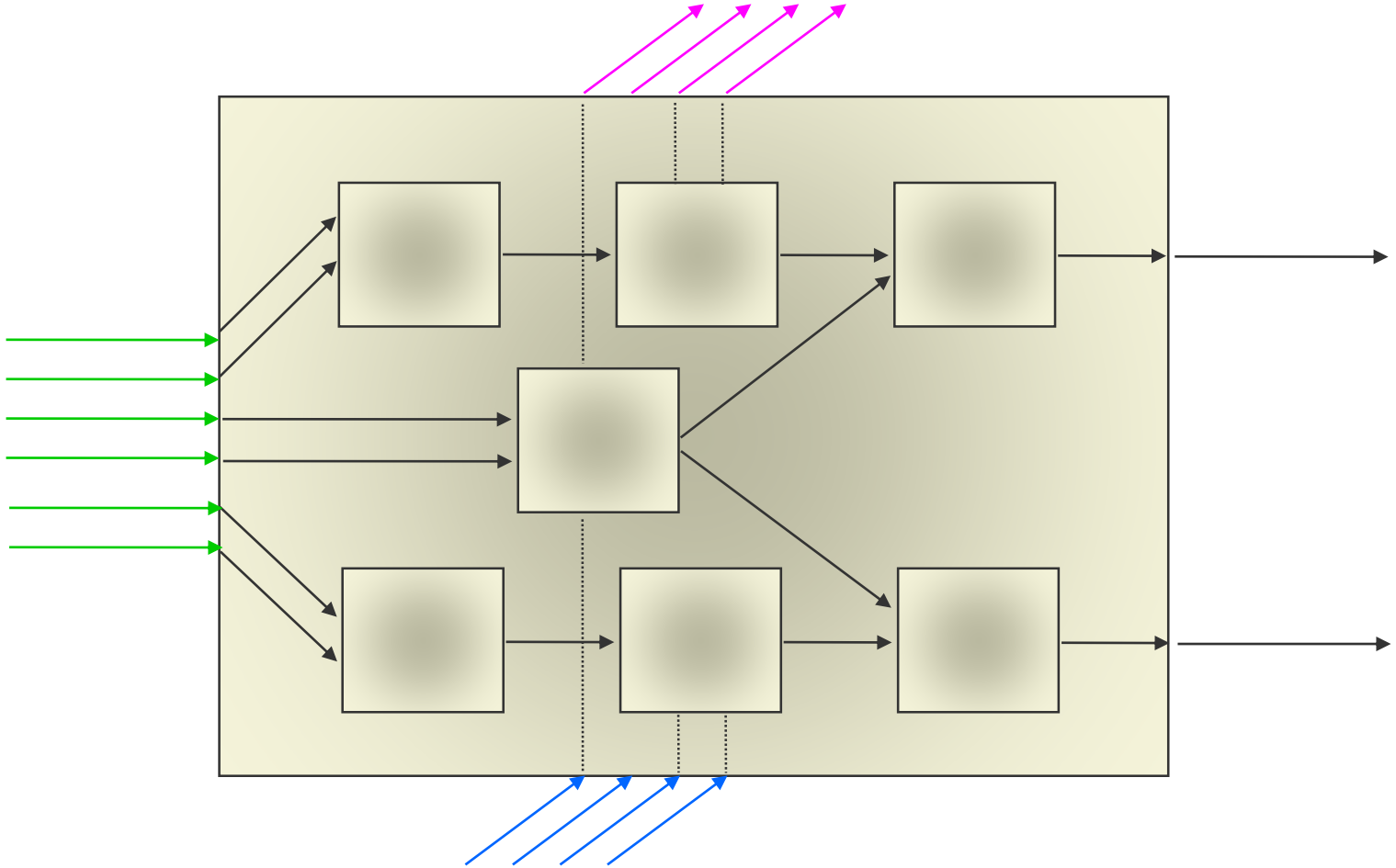
Overview of LCA processes see:
http://www.lcafood.dk/LCA/LCA.htm#1



Unit Processes are the accounting elements

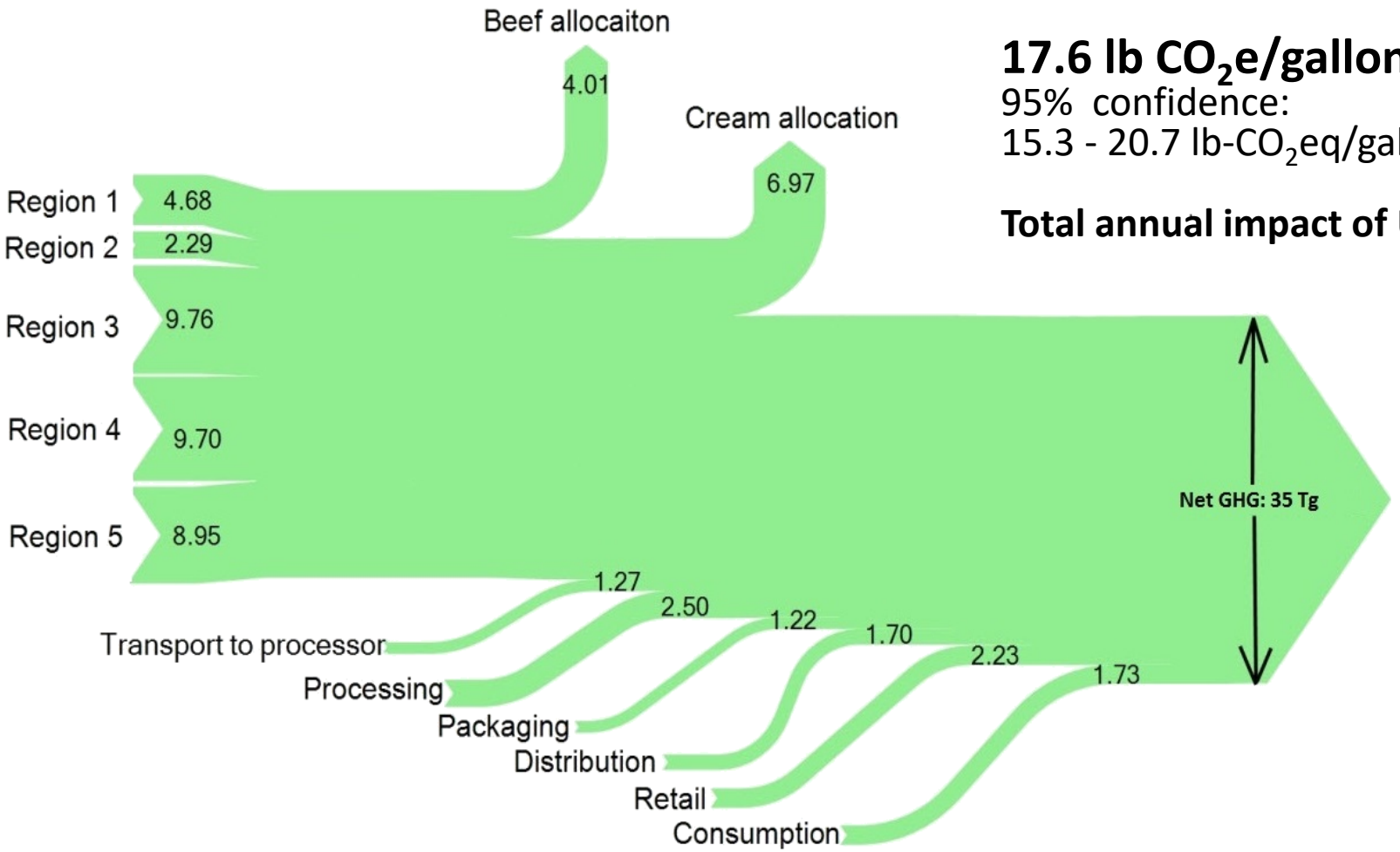


Unit Processes are the accounting elements linked together in Reference Flow



How is LCA used?

Identifying opportunities for improvement



GHG Emissions from 1 gallon of milk

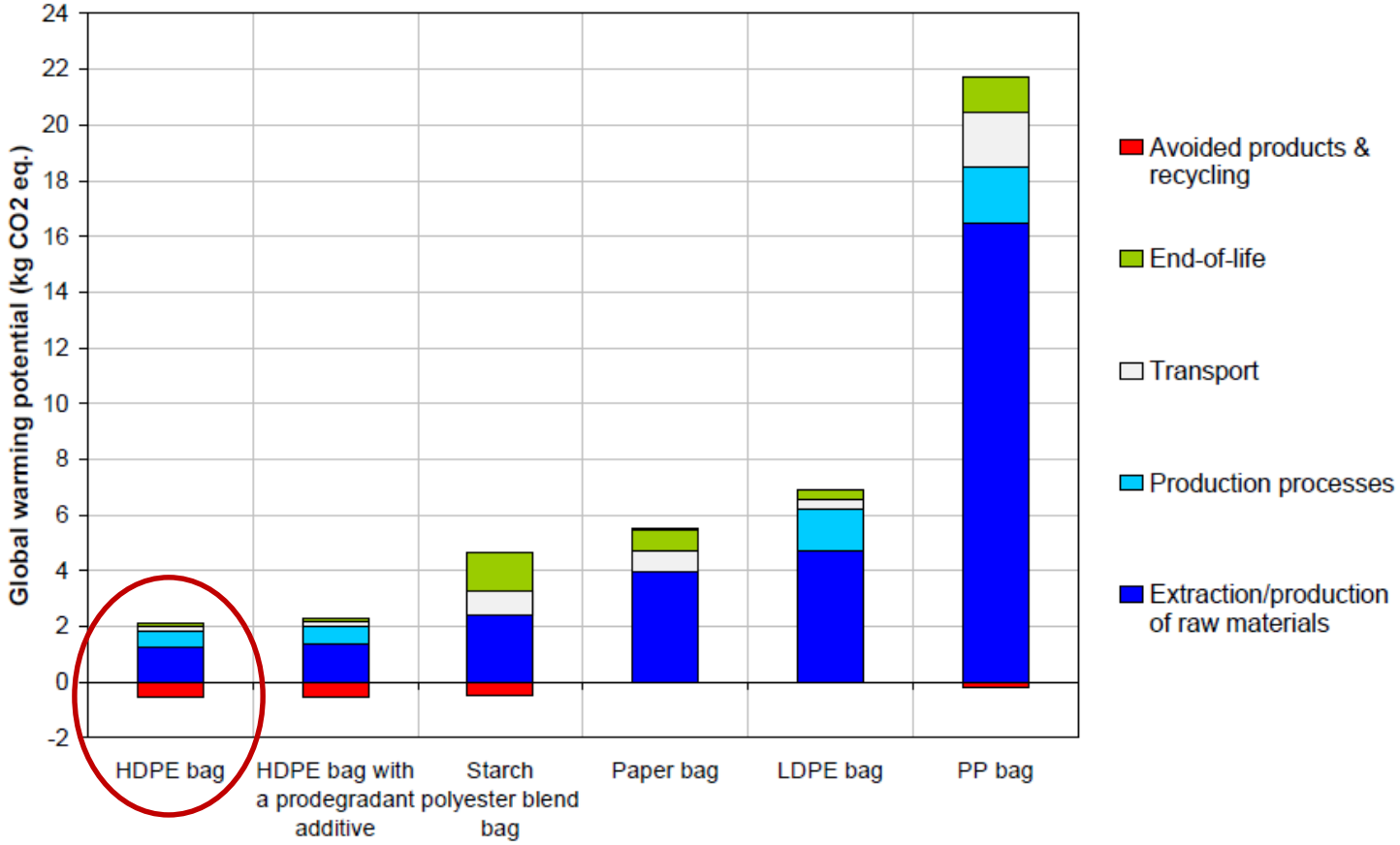
17.6 lb CO_2e/gallon
95% confidence:
15.3 - 20.7 lb-CO_2eq/gallon

Total annual impact of US Milk Supply Chain: 35 Tg

How is LCA used?

Informing decisions

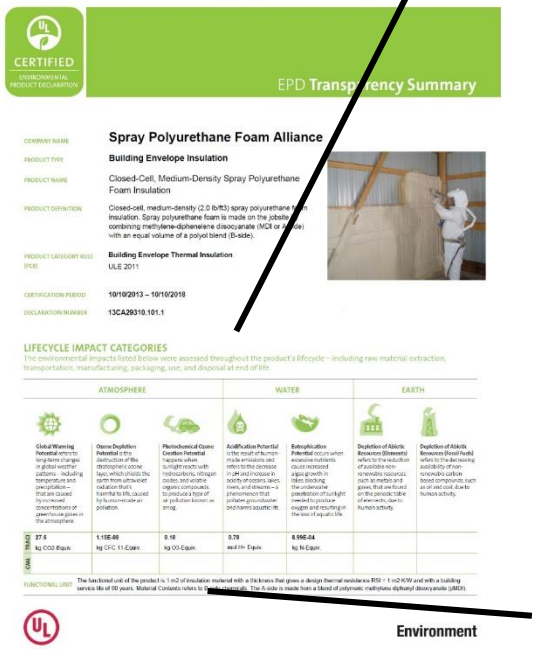
Modified from Civancik-Uslu, D., Puig, R., Hauschild, M., & Fullana-i-Palmer, P. (2019). Life cycle assessment of carrier bags and development of a littering indicator. *Science of the Total Environment*, *685*, 621-630.



If the only metric of concern is GWP, then the decision on what type of grocery bag you use is clear: HDPE

How is LCA used?

Marketing/Environmental Product Declarations (EPDs)


CERTIFIED

EPD Transparency Summary

Spray Polyurethane Foam Alliance

Building Envelope Insulation

Closed-Cell, Medium-Density Spray Polyurethane Foam Insulation

Building Envelope Thermal Insulation

ULE 2011

10/10/2013 – 10/10/2018

13CA29310.101.1

LIFECYCLE IMPACT CATEGORIES

Environment

LIFECYCLE IMPACT CATEGORIES

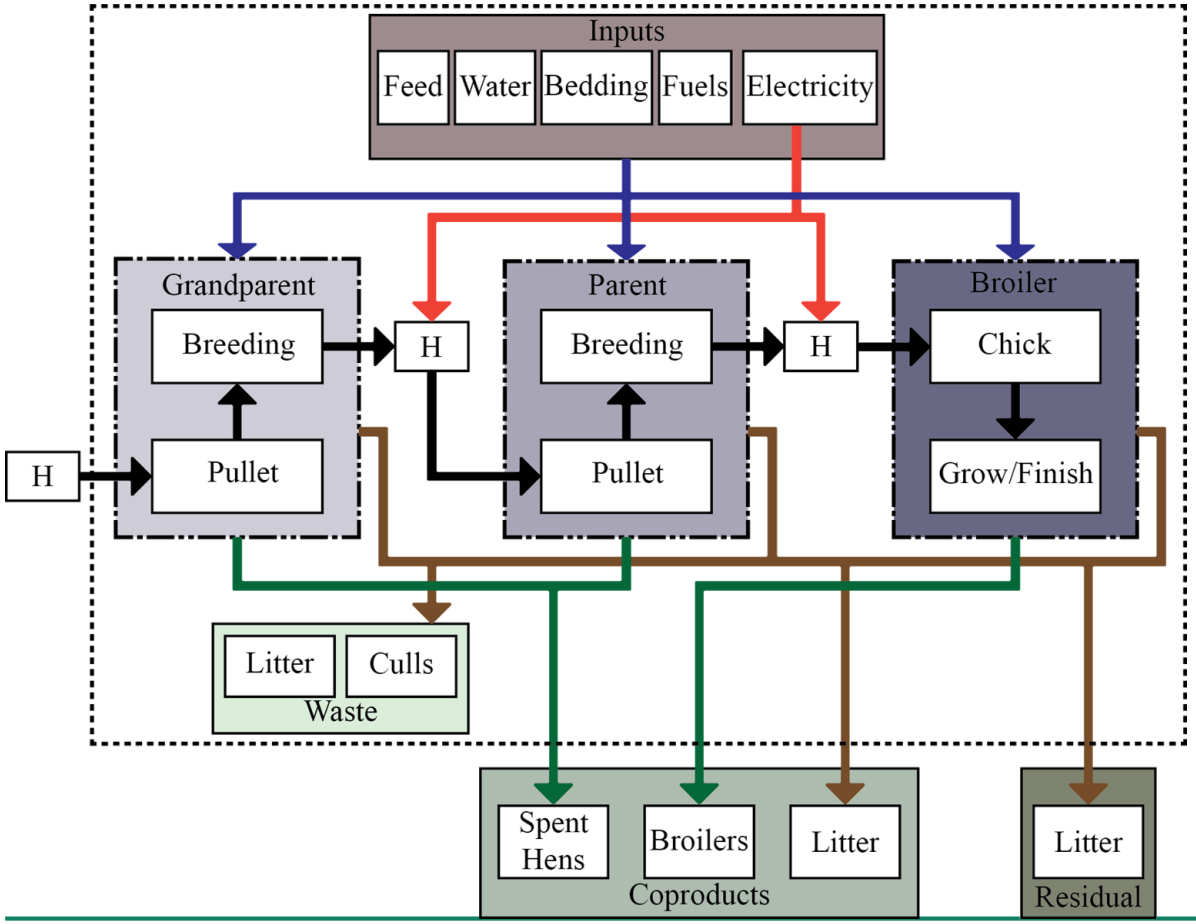
The environmental impacts listed below were assessed throughout the product's lifecycle – including raw material extraction, transportation, manufacturing, packaging, use, and disposal at end of life.

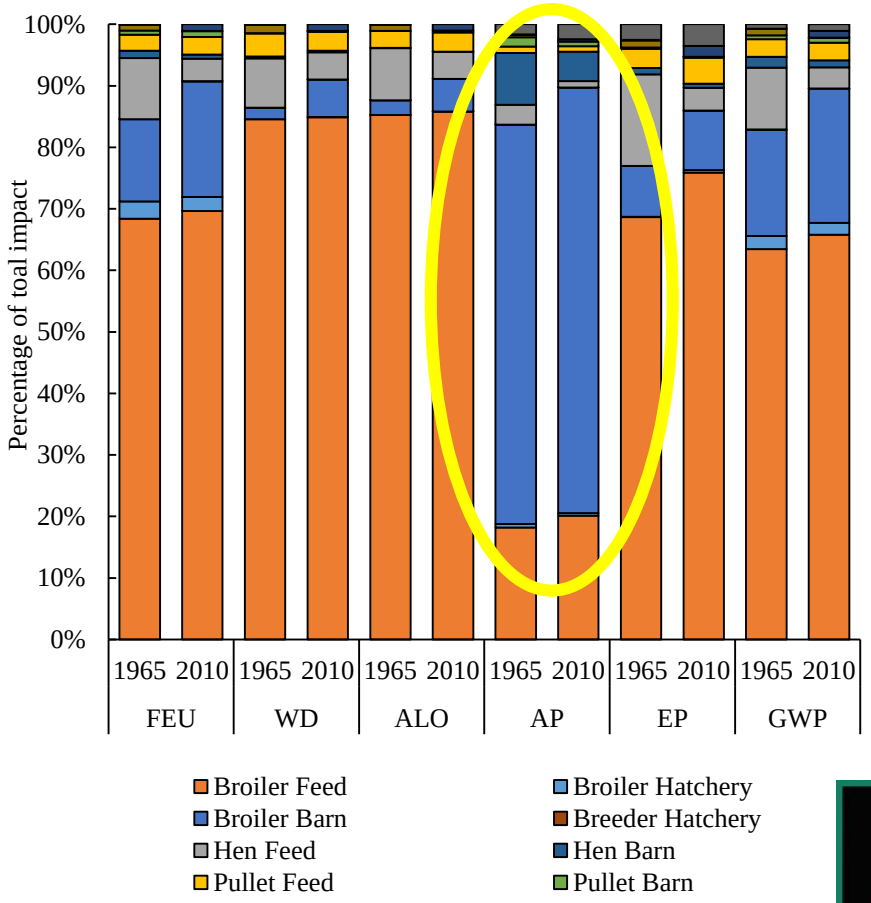
	ATMOSPHERE			WATER		EARTH	
	Global Warming Potential refers to long-term changes in global weather patterns – including temperature and precipitation – that are caused by increased concentrations of greenhouse gases in the atmosphere.	**Ozone Depletion Potential** is the destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation that's harmful to life, caused by human-made air pollution.	**Photochemical Ozone Creation Potential** happens when sunlight reacts with hydrocarbons, nitrogen oxides, and volatile organic compounds, to produce a type of air pollution known as smog.	**Acidification Potential** is the result of human-made emissions and refers to the decrease in pH and increase in acidity of oceans, lakes, rivers, and streams – a phenomenon that pollutes groundwater and harms aquatic life.	**Eutrophication Potential** occurs when excessive nutrients cause increased algae growth in lakes, blocking the underwater penetration of sunlight needed to produce oxygen and resulting in the loss of aquatic life.	**Depletion of Abiotic Resources (Elements)** refers to the reduction of available non-renewable resources, such as metals and gases, that are found on the periodic table of elements, due to human activity.	**Depletion of Abiotic Resources (Fossil Fuels)** refers to the decreasing availability of non-renewable carbon-based compounds, such as oil and coal, due to human activity.
TRACI	**27.6** kg CO2-Equiv.	**1.15E-08** kg CFC 11-Equiv.	**0.18** kg O3-Equiv.	**0.78** mol H+ Equiv.	**8.99E-04** kg N-Equiv.		
CML							

FUNCTIONAL UNIT The functional unit of the product is 1 m2 of insulation material with a thickness that gives a design thermal resistance RSI = 1 m2·K/W and with a building service life of 60 years. Material Contents refers to B-side chemicals. The A-side is made from a blend of polymeric methylene diphenyl diisocyanate (pMDI).

How is LCA used?

Identifying relevant indicators

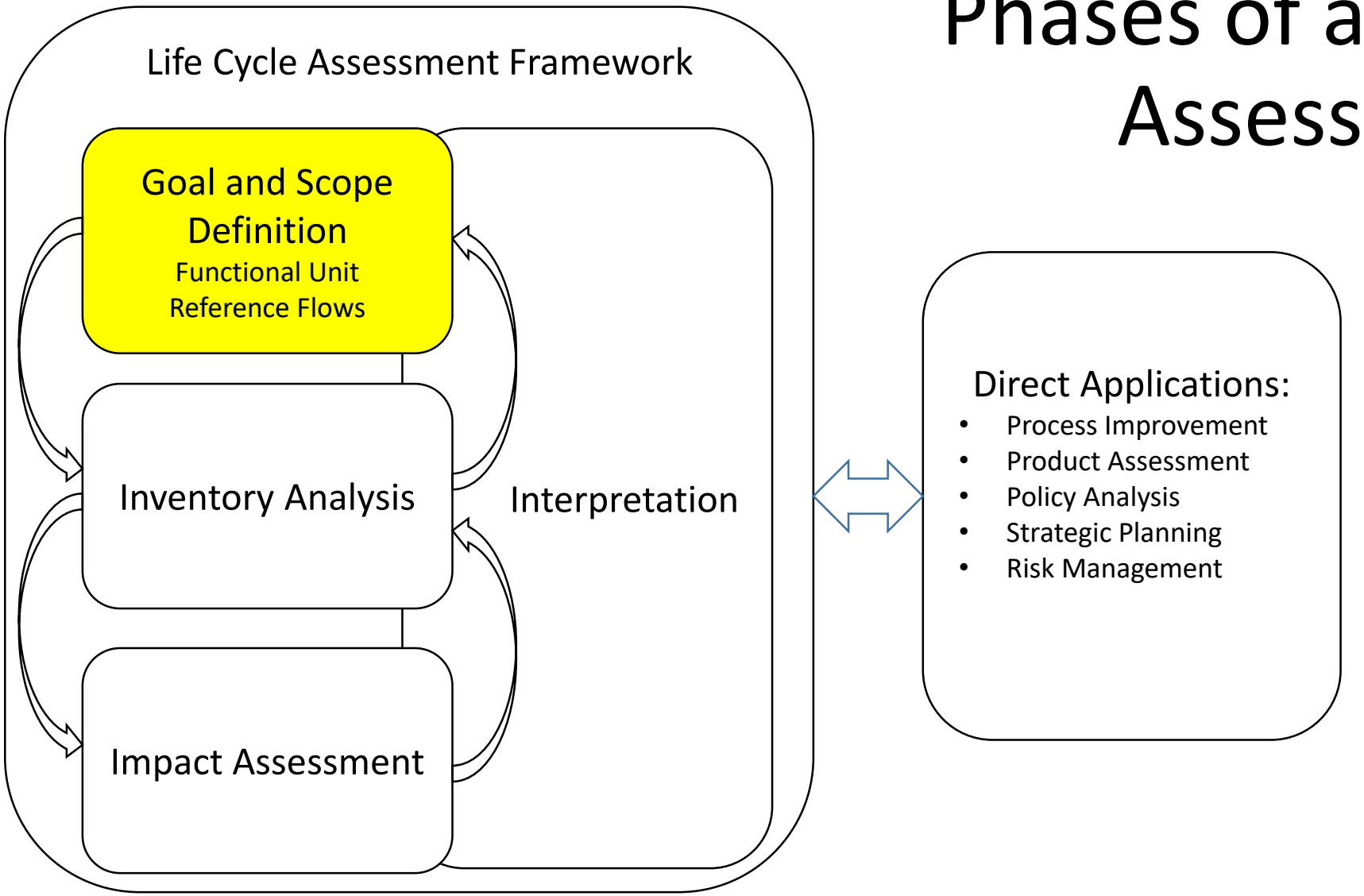




ISO Standards for LCA

- ISO 14040:2006 describes LCA principles and methodological framework
- ISO 14044: 2006 describes specific methodological and reporting requirements as well as requirements for critical review
- ISO 14046: 2014 concerns water footprint calculations
- ISO 14067: 2018 concerns product carbon footprint calculations
- ISO 14044 Amendment 1: 2017 expands the scope of 14044 to cover all footprints
- ISO 14071: 2014 provides additional coverage of LCA critical review processes
- ISO 14072: 2014 extends the application of LCA to organizations

Phases of a Life Cycle Assessment



Direct Applications:

- Process Improvement
- Product Assessment
- Policy Analysis
- Strategic Planning
- Risk Management

Phase 1: Goal and scope definition
Intended audience/application

- The way an LCA is conducted depends on who will use the information and for what.
- How will the goal and scope change if an LCA is conducted for…
  - Consumers?
  - Producers?
  - Policy-makers?

Phase 1: Goal and scope definition
Functional unit and Systems Boundaries

- Functional Unit: The quantified performance of a product system for use as a reference unit (ISO 2006).
- Systems Boundaries define the unit processes to be included.
- Ideally inputs/outputs are elemental at the boundaries.
- Ideal system boundaries are not always possible:
  - Cost
  - Data availability

Phase 1: Goal and scope definition
Allocation

- Many processes yield more than one output
  - Co-products share burdens through an allocation process
    - Economic
    - Mass
  - Waste treatment burdens attributed to co-products
- How do we allocate the environmental impacts if a co-product is not used in our product system?

Wilfart, A., Gac, A., Salaün, Y., Aubin, J., & Espagnol, S. (2021). Allocation in the LCA of meat products: is agreement possible?. *Cleaner Environmental Systems*, *2*, 100028.

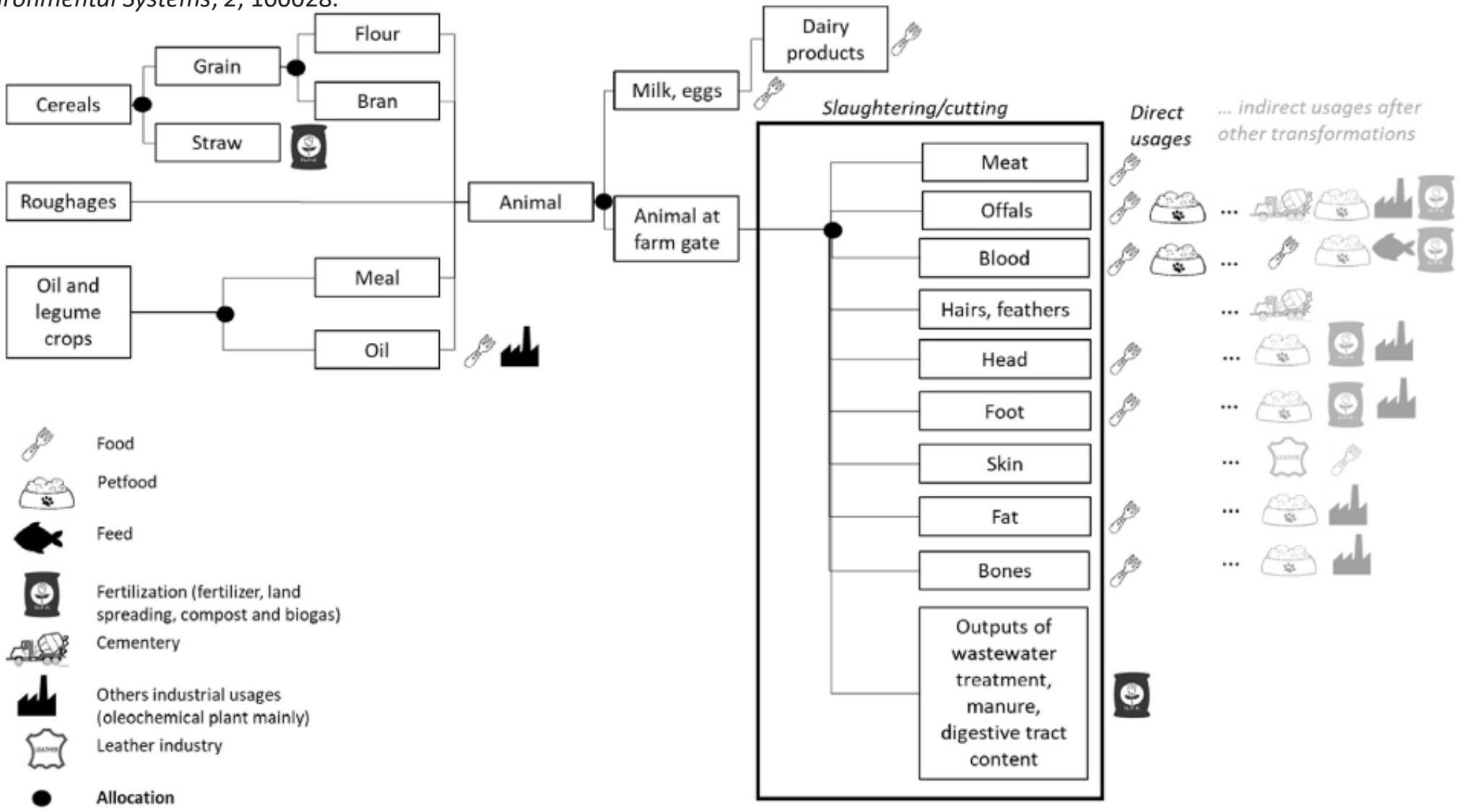


Fig. 3. Overview of the meat supply chain and its co-products with the associated allocation stages (●) and their final destination.

Celebrating 50 Years as the Trusted Source for Agricultural Science and Technology

Wilfart, A., Gac, A., Salaün, Y., Aubin, J., & Espagnol, S. (2021). Allocation in the LCA of meat products: is agreement possible?. *Cleaner Environmental Systems*, *2*, 100028.

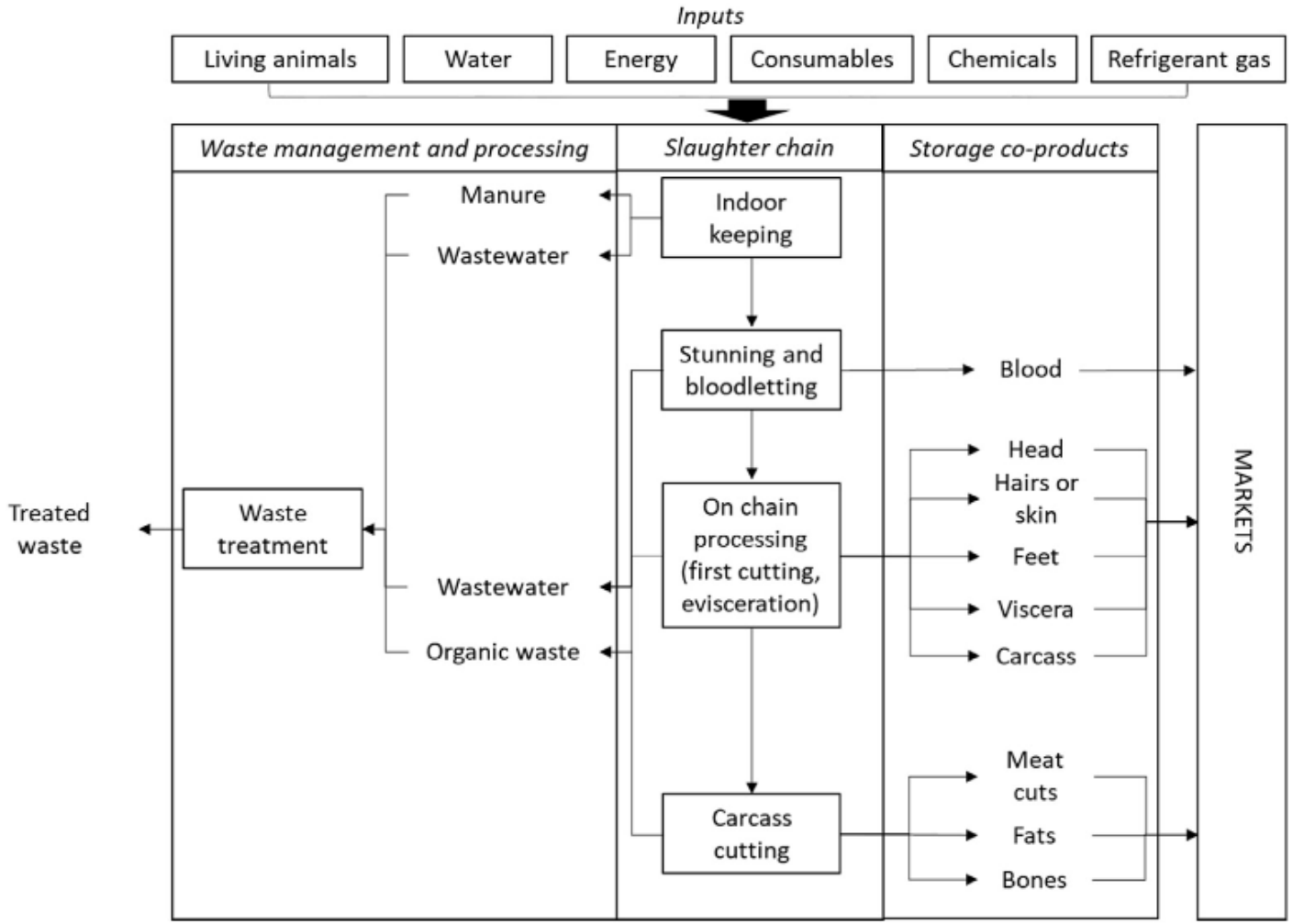


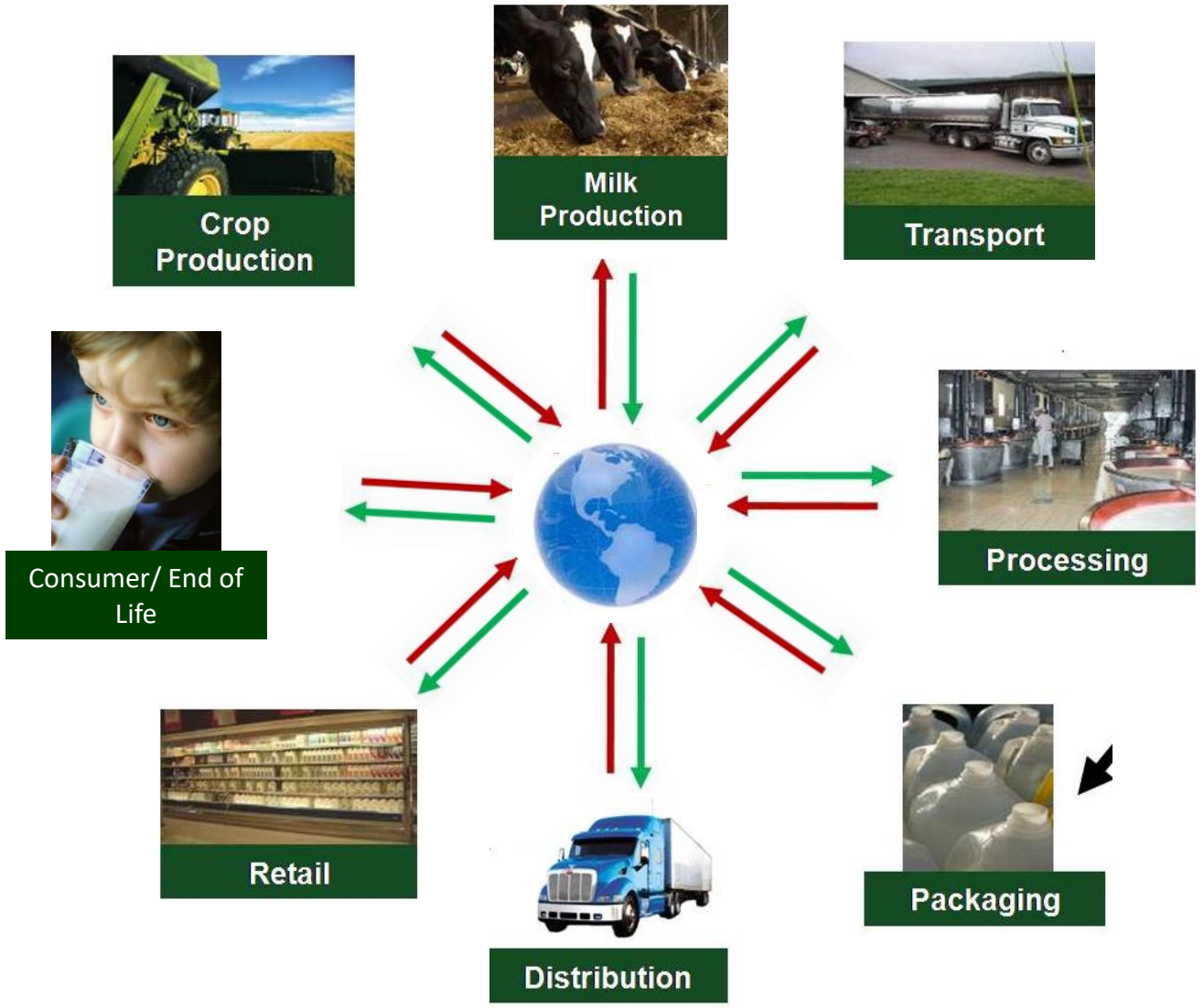
Fig. 4. Flowchart of a slaughterhouse.

Phase 1: Goal and scope definition Allocation

- ISO says start with “underlying physical relationships”
  - Mass, energy content, etc.
- If this fails, use another method.
  - Most commonly economic, either the cost to produce or the price received.
- Allocation should be consistent throughout LCAs in any application.

FAO LEAP Allocation Rules are international standard for animal agriculture

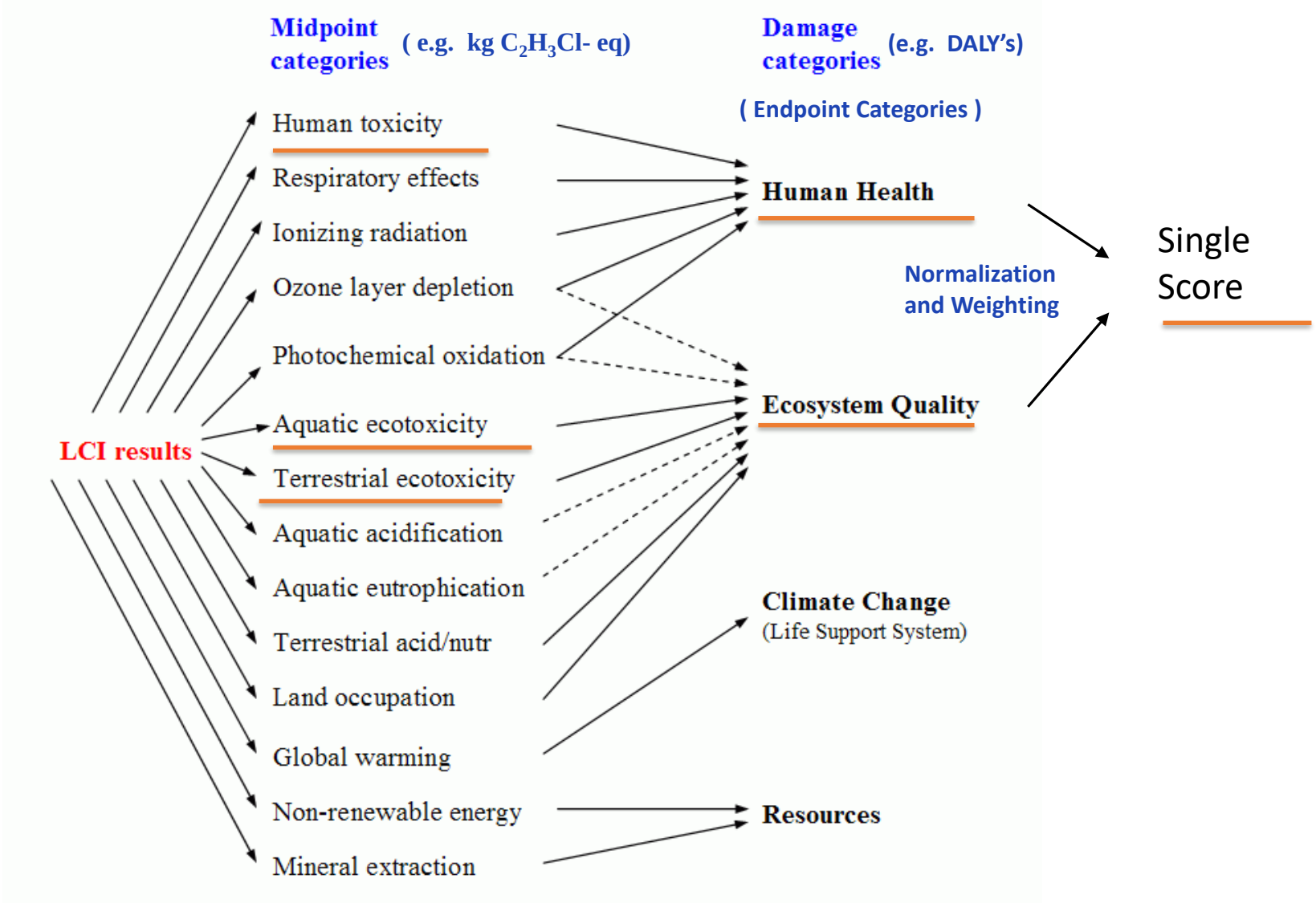
Year of publication: 2016
Pages: #232 p.
ISBN: 978-92-5-109523-2
Author: FAO
Series number: VERSION 1
Publisher: FAO
Access at:
https://www.fao.org/publications/card/en/c/cd7ec1b8-7801-4ce1-87ed-0bdb575672a5/



Life Cycle Assessment for Environmental Impacts

High Confidence/ Lower Understanding

Low Confidence/ Greater Understanding



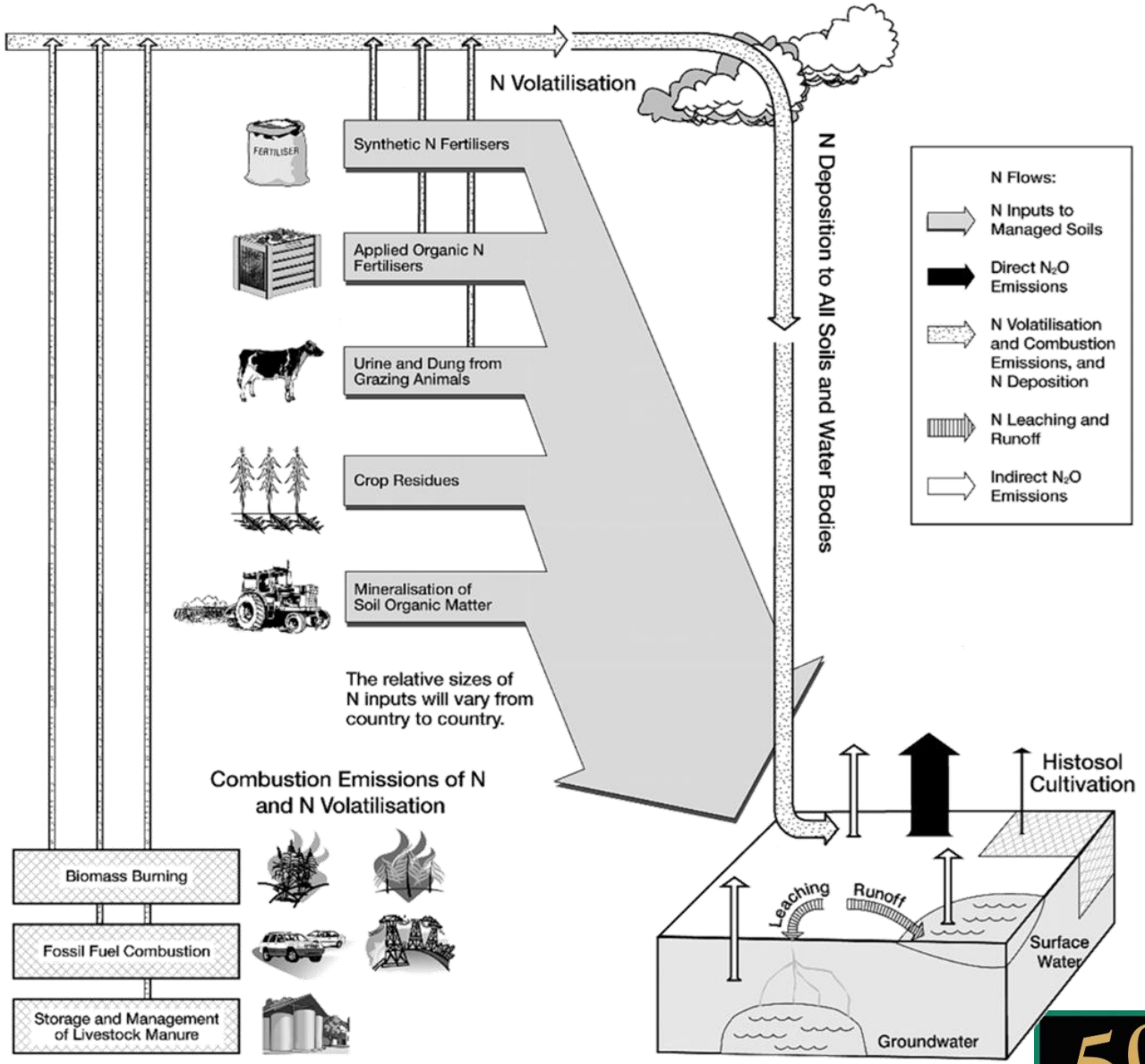
LCIA: Quantifying Systems Impacts

Agricultural LCAs are particularly complex…

Ag LCAs touch almost every part of the Biosphere and Technosphere.

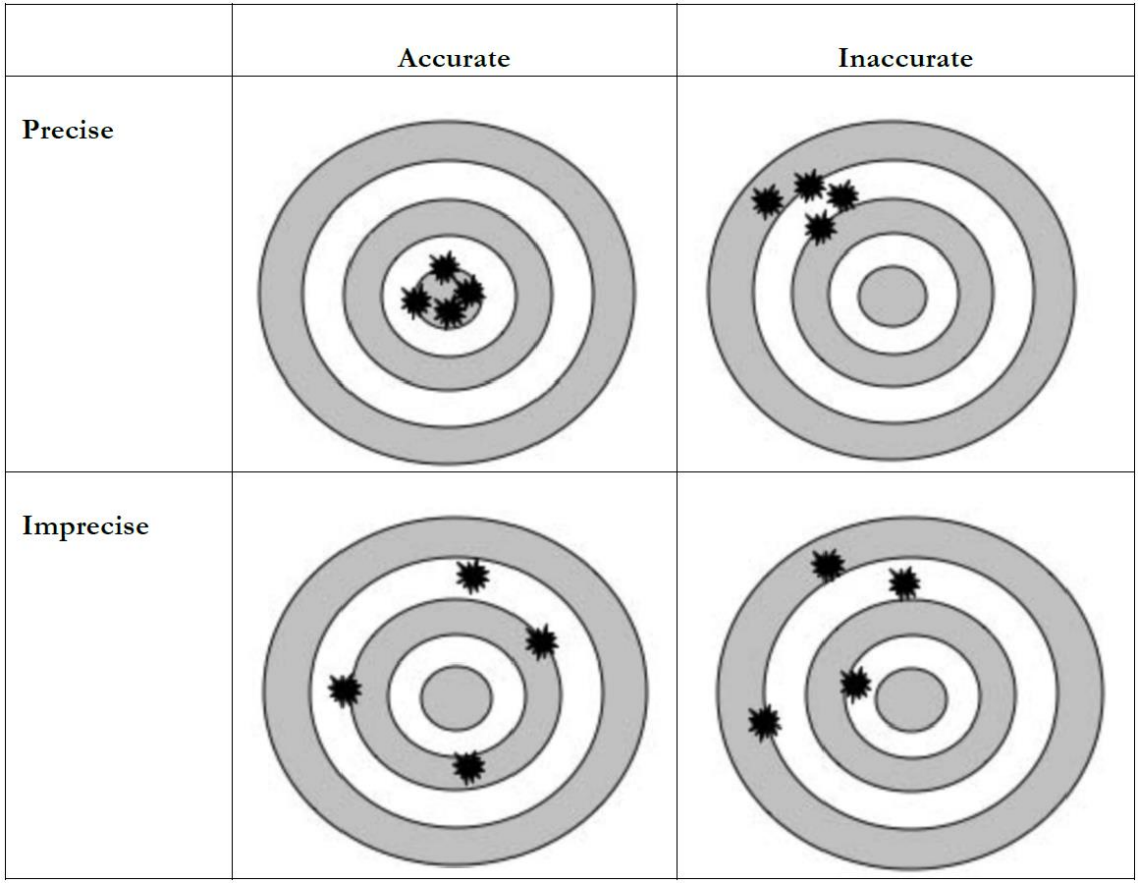
Nitrogen use impacts are particularly complex.

https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf



Data Quality in Life Cycle Inventory

- Primary sources
  - data comes directly from the entity collecting the data and/or analyzing it to find a result
- Secondary sources
  - one that cites or reuses the information from the primary source
- Simulated data
  - Data from process models that simulate conditions being analyzed

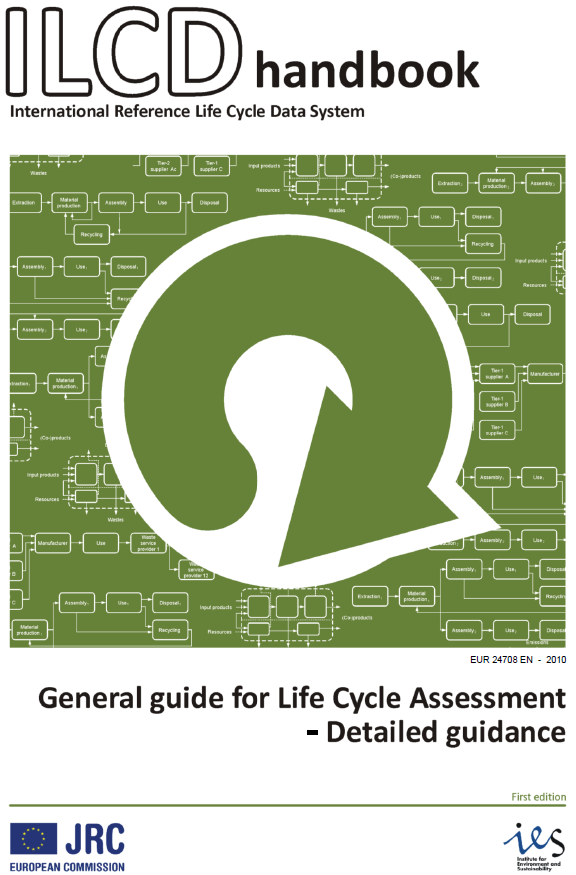


Source: NOAA 2012

LCA Guidance Materials

Life Cycle Thinking (LCT) and LCA support Sustainable Consumption Practices (SCP)

- This guide is a component of the International Reference Life Cycle Data System (ILCD) Handbook.
- It provides technical guidance for detailed Life Cycle Assessment (LCA) studies and provides the technical basis to derive product-specific criteria, guides, and simplified tools.
- It is based on and conforms to the ISO 14040 and 14044 standards on LCA.



https://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf

CAST Social Media

CAST expands its outreach through the active use of social media

Blog

cast-science.org/news

LinkedIn

linkedin.com/company/CASTagScience

Facebook

@CASTagScience

Pinterest

pinterest.com/castagscience

Twitter

@CASTagScience

YouTube

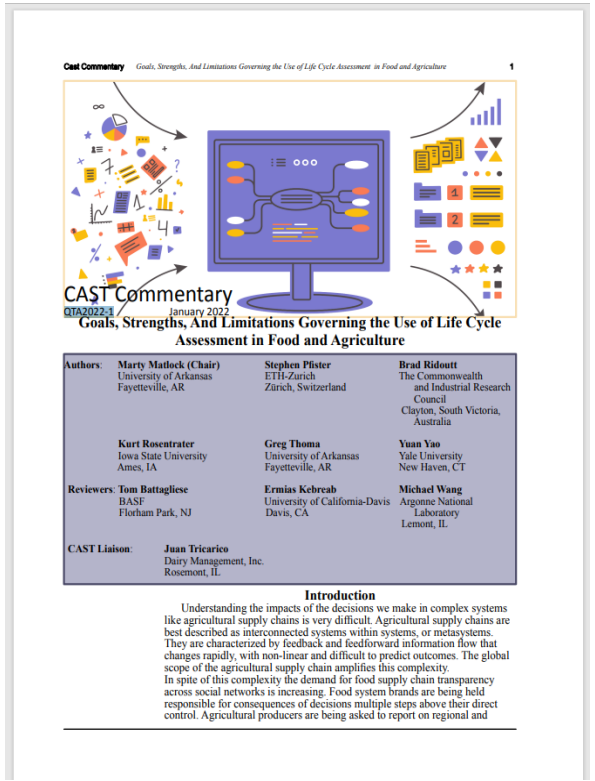
youtube.com/user/CASTagScience

www.cast-science.org

Thank You to Our Presenter & Panelists!

This CAST Commentary is available at: **cast-science.org/publications**

- **Marty Matlock**—mmatlock@uark.edu
- **Kurt Rosentrater**—karosent@iastate.edu
- **Juan Tricarico**—Juan.Tricarico@dairy.org
- **Yuan Yao**—y.yao@yale.edu



Cast Commentary Goals, Strengths, And Limitations Governing the Use of Life Cycle Assessment in Food and Agriculture 1

CAST Commentary
QTA2022-1 January 2022

Goals, Strengths, And Limitations Governing the Use of Life Cycle Assessment in Food and Agriculture

Authors: **Marty Matlock (Chair)** University of Arkansas Fayetteville, AR; **Stephen Pfister** ETH-Zurich Zürich, Switzerland; **Brad Ridoutt** The Commonwealth and Industrial Research Council Clayton, South Victoria, Australia; **Kurt Rosentrater** Iowa State University Ames, IA; **Greg Thoma** University of Arkansas Fayetteville, AR; **Yuan Yao** Yale University New Haven, CT

Reviewers: **Tom Battagliese** BASF Florham Park, NJ; **Ermias Kebreab** University of California-Davis Davis, CA; **Michael Wang** Argonne National Laboratory Lemont, IL

CAST Liaison: **Juan Tricarico** Dairy Management, Inc. Rosemont, IL

Introduction

Understanding the impacts of the decisions we make in complex systems like agricultural supply chains is very difficult. Agricultural supply chains are best described as interconnected systems within systems, or metasystems. They are characterized by feedback and feedforward information flow that changes rapidly, with non-linear and difficult to predict outcomes. The global scope of the agricultural supply chain amplifies this complexity.
In spite of this complexity the demand for food supply chain transparency across social networks is increasing. Food system brands are being held responsible for consequences of decisions multiple steps above their direct control. Agricultural producers are being asked to report on regional and

Thank you for joining us today!

Kent Schescke
Executive Vice President/CEO
kschescke@cast-science.org
515.292.2125