Sustainability, Life Cycle Assessment and Energy Use in cotton

Zara Clayton-Niederman,
Center for Agricultural and Rural Sustainability

Marty Matlock, PhD, P.E. C.S.E.
Area Director, Center for Agricultural and Rural Sustainability

Lanier Nalley PhD
Department of Agricultural Economics

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Sustainability

*"I shall not today attempt further to define … and perhaps I could never succeed in intelligibly doing so. But **I know it when I see it…**"*

Justice Potter Stewart, Jacobellis v. Ohio, (1964)

Defining Sustainability

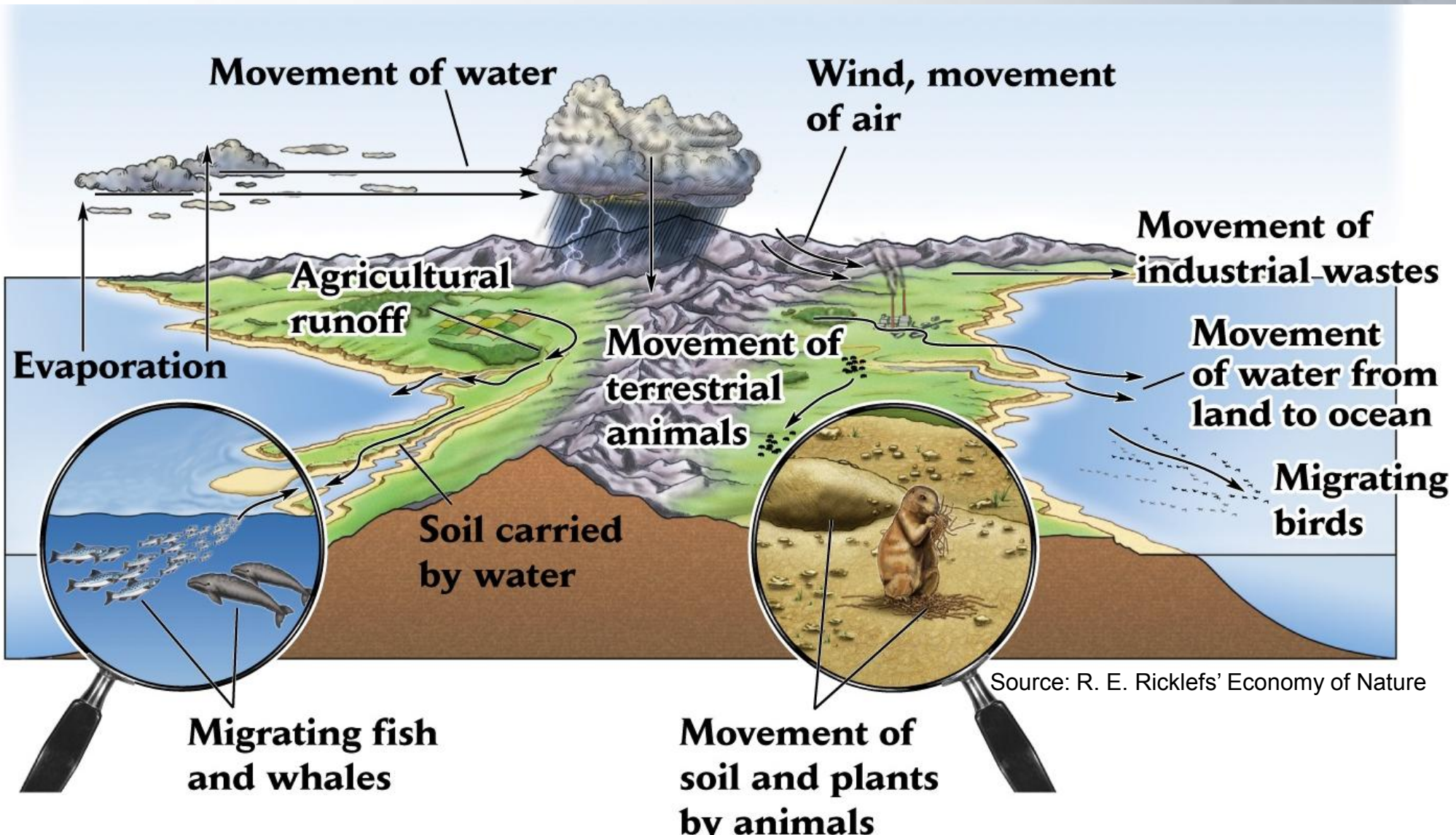
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Brundtland Commission Report, 1987

Defining Sustainability may actually be easier than "knowing it when you see it." Sustainability needs to be measured.

Everything is Connected
Whether measurable or not

Our Actions Matter



Source: R. E. Ricklefs' Economy of Nature

Everyone Is Trying to Define Sustainability

Labels help us make quick decisions
But, are they the right decisions?

<u>Some of the Many Labels</u>
Organic
Sustainable
Green
Carbon Neutral
Natural / Naturally Grown
Locally Grown
Fair Trade
Pesticide Free
Hormone Free
Free Range

Measuring Sustainability:

Metrics: Need a way to measure sustainability

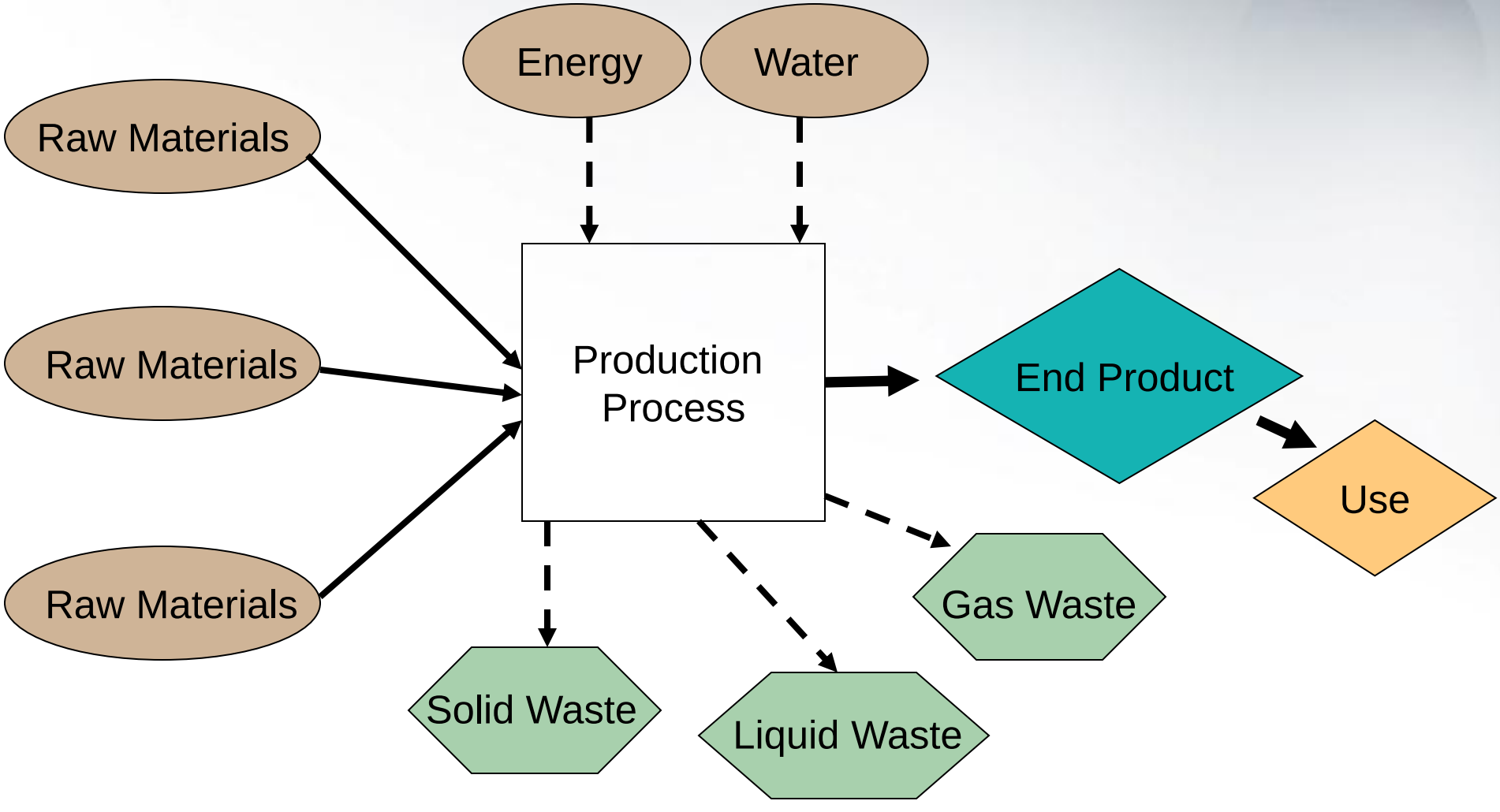
Baseline: Need a way to measure change over time

Life Cycle Assessment (LCA): One method for measuring the inputs and outputs in a process in a step *towards* quantifying sustainability

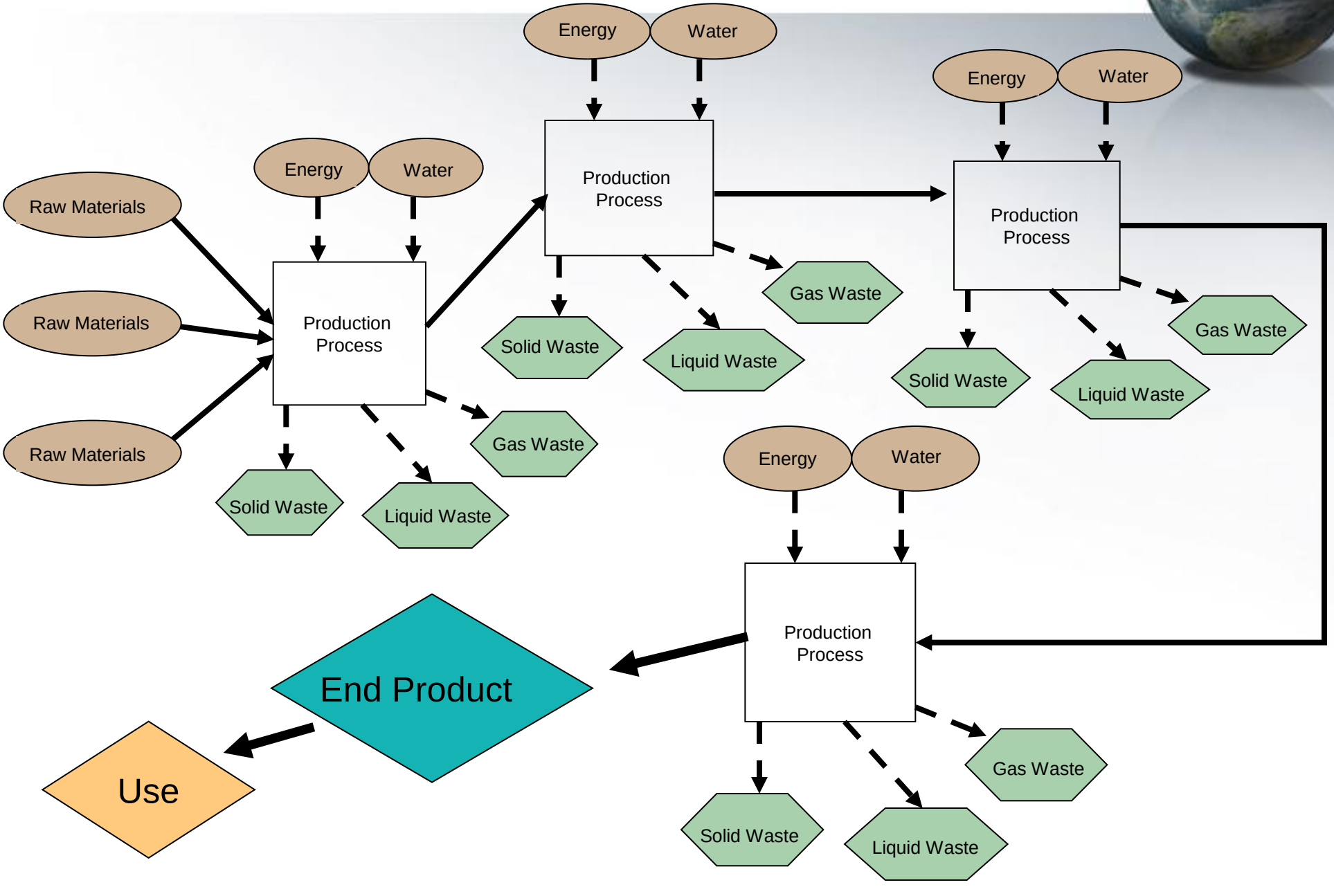
Why bother measuring the sustainability and carbon footprint of an industry?

- Soon some retailers may require it
- Either an industry defines it for themselves or lets the retailer define it for them!

Every Process has Inputs And Outputs



The More Processes, The More Complexity



Life Cycle Analysis Overview

Goal of LCA: Quantify inputs and outputs for a system in terms of a standardized unit of measure.

The scope and structure of the LCA is directly dependent upon the unit of measure (functional unit):

1. Energy embodied in a single product;
2. Greenhouse gasses produced per unit product;
3. Volume of water consumed per mass of product…

Goal and Scope of LCA must be formulated at the outset of the project, and the **functional unit** must be defined.

LCA Process is described in ISO 14040 and 14044 Standards.

Cotton LCA Case Study
Goal Definition and Scope

- **Develop** a model
- **Estimate** the energy embodied in a unit (tonne) of cotton produced (lint plus seed)
- **Compare** the total energy (MJ) required over varying cotton production strategies

Cotton LCA Case Study

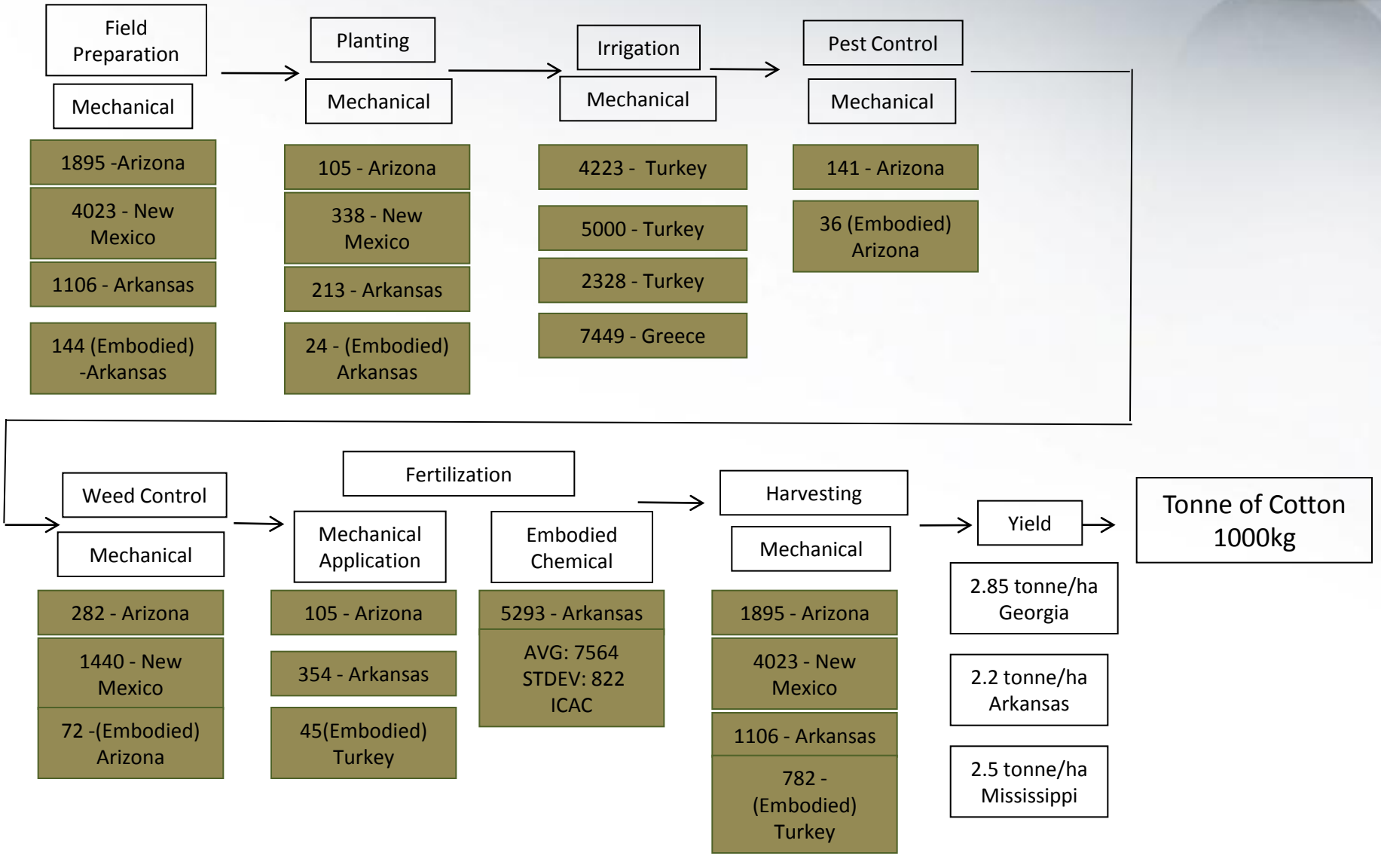
Life Cycle Methodology

Inputs for Cotton Production (MJ/ha)

- 1. Field Preparation
- 2. Planting
- 3. Field Operations
  - a. Irrigation
  - b. Weed Control
  - c. Pest Control
  - c. Fertilization
- 4. Harvesting

$$\frac{\text{Sum of Inputs (MJ/ha)}}{\text{Yield (Tonnes/ha)}} = \text{Energy of Production (MJ/Tonne)}$$

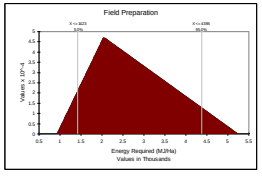
Cotton LCA Case Study
Life Cycle Inventory



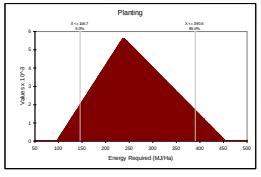
Cotton LCA Case Study

Uncertainty Analysis

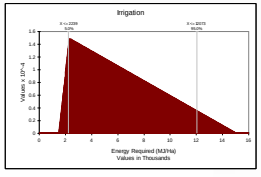
Field Preparation
Mechanical



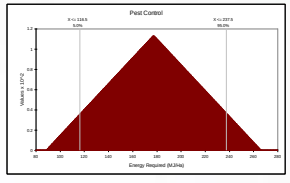
Planting
Mechanical



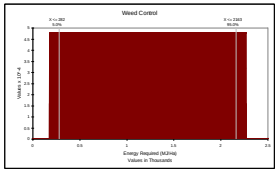
Irrigation
Mechanical



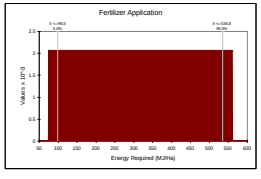
Pest Control
Mechanical



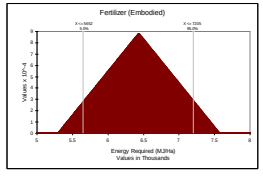
Weed Control
Mechanical



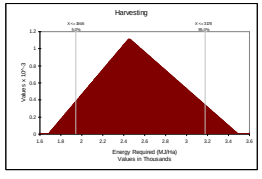
Fertilization
Mechanical Application



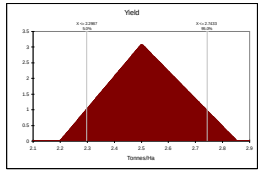
Fertilization
Embodied Chemical



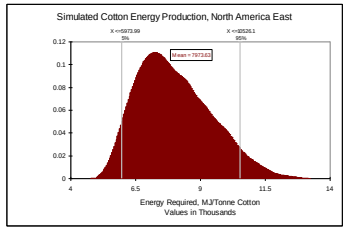
Harvesting
Mechanical



Yield

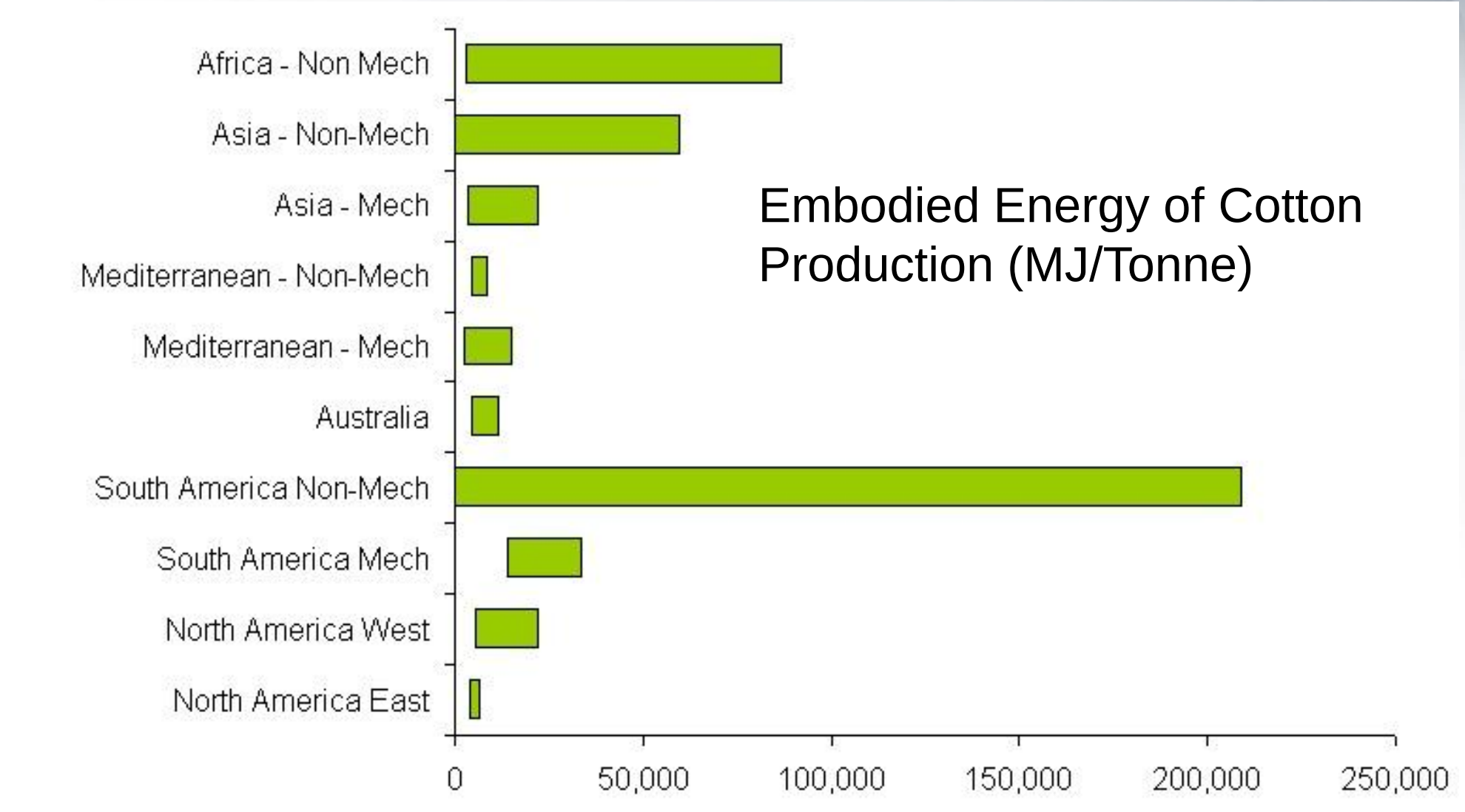


MJ/Tonne of Cotton



Cotton LCA Case Study

Assessment and Comparison



Cotton LCA Case Study

Net Energy of Cotton Production

Net Potential Recovered Energy (MJ/ha)

- 1. Cotton Energy Content (MJ/Tonne)
  - a. CS Oil Energy (MJ/Tonne)
  - b. CS Meal Energy (MJ/Tonne)
- 2. Raw Cotton Yield (Tonne/ha)
  - a. CS Oil Yield (Tonne/ha)
  - b. CS Meal Yield (Tonne/ha)

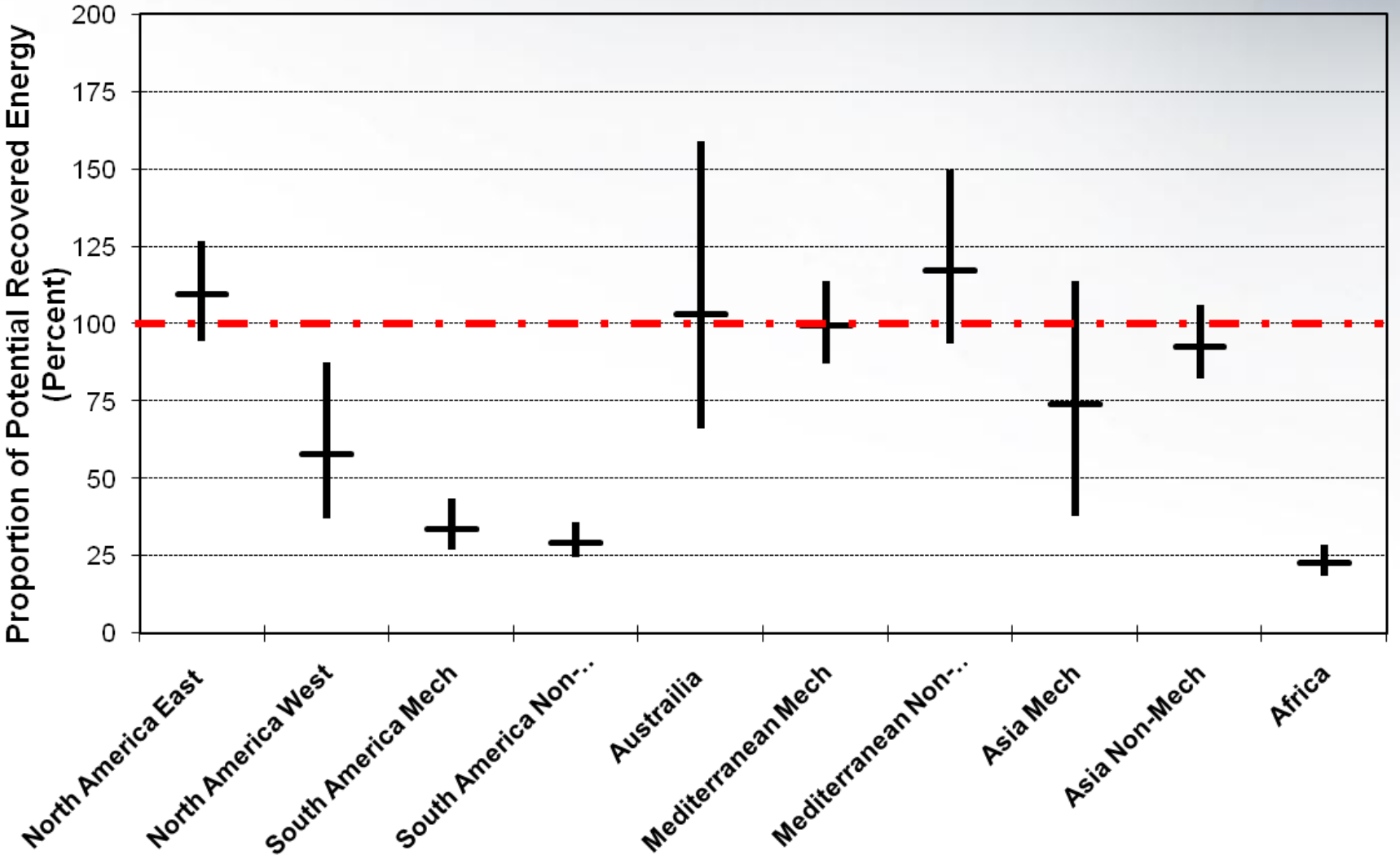
→

- 3. Total Cotton PRE (MJ/ha)
  - a. CS Oil PRE (MJ/ha)
  - b. CS Meal PRE (MJ/ha)

Net Potential Recovered Energy (MJ/ha) = **Energy of Production (MJ/ha)** - **Total Cotton PRE (MJ/ha)**

Cotton LCA Case Study Scenario Analysis

Net Energy of Cotton Production



Energy Is Only ONE metric of Sustainability

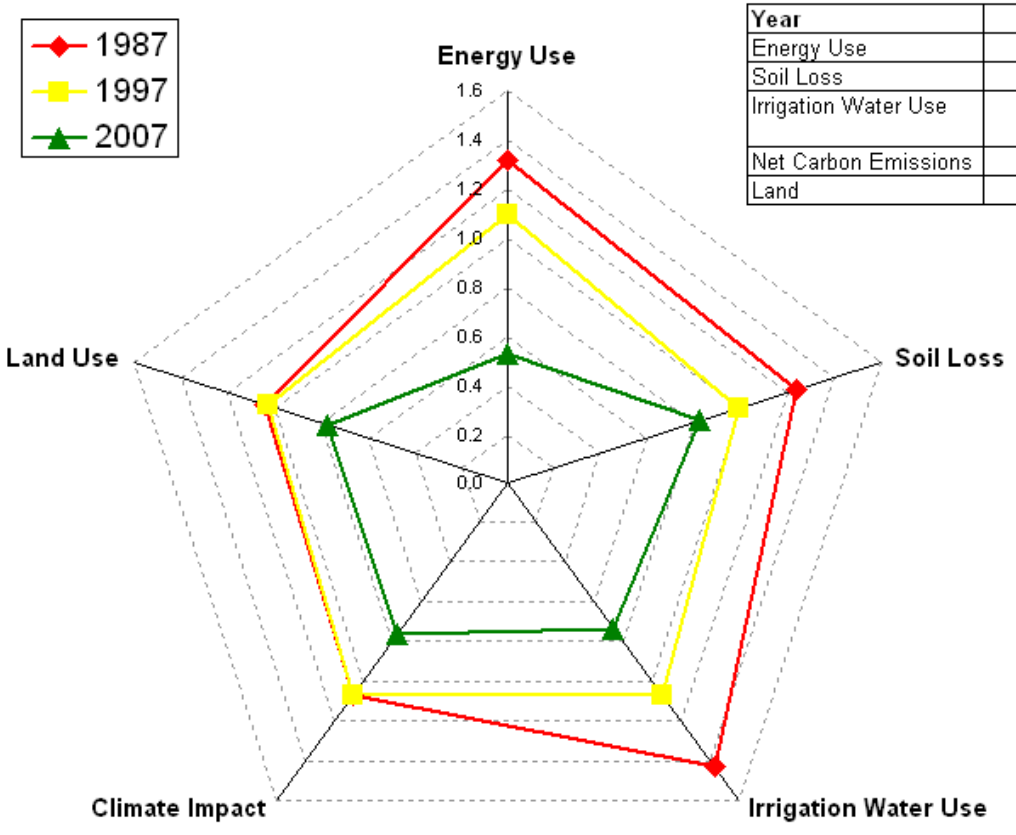
Components of a Sustainability Index

	Environmental Outcomes							Social and Economic Outcomes							Health and Safety Outcomes	
	Land	Soil	Water Use	Water Quality	Energy	Climate	Biodiversity	Producer Income	Labor	Productivity	Competing Land and product uses	Availability	Post Harvest Loss	Consumer Demand	Nutrition (access to calories, etc)	Safety
International Scale																
National Scale	x	x	X		x	x				x						
Regional Scale																
Local Scale																

Field to Market

Life Cycle Assessment Case Study: US Cotton Over Time

Cotton Efficiency Indicators (Per Unit of Output, Index 2000 = 1)



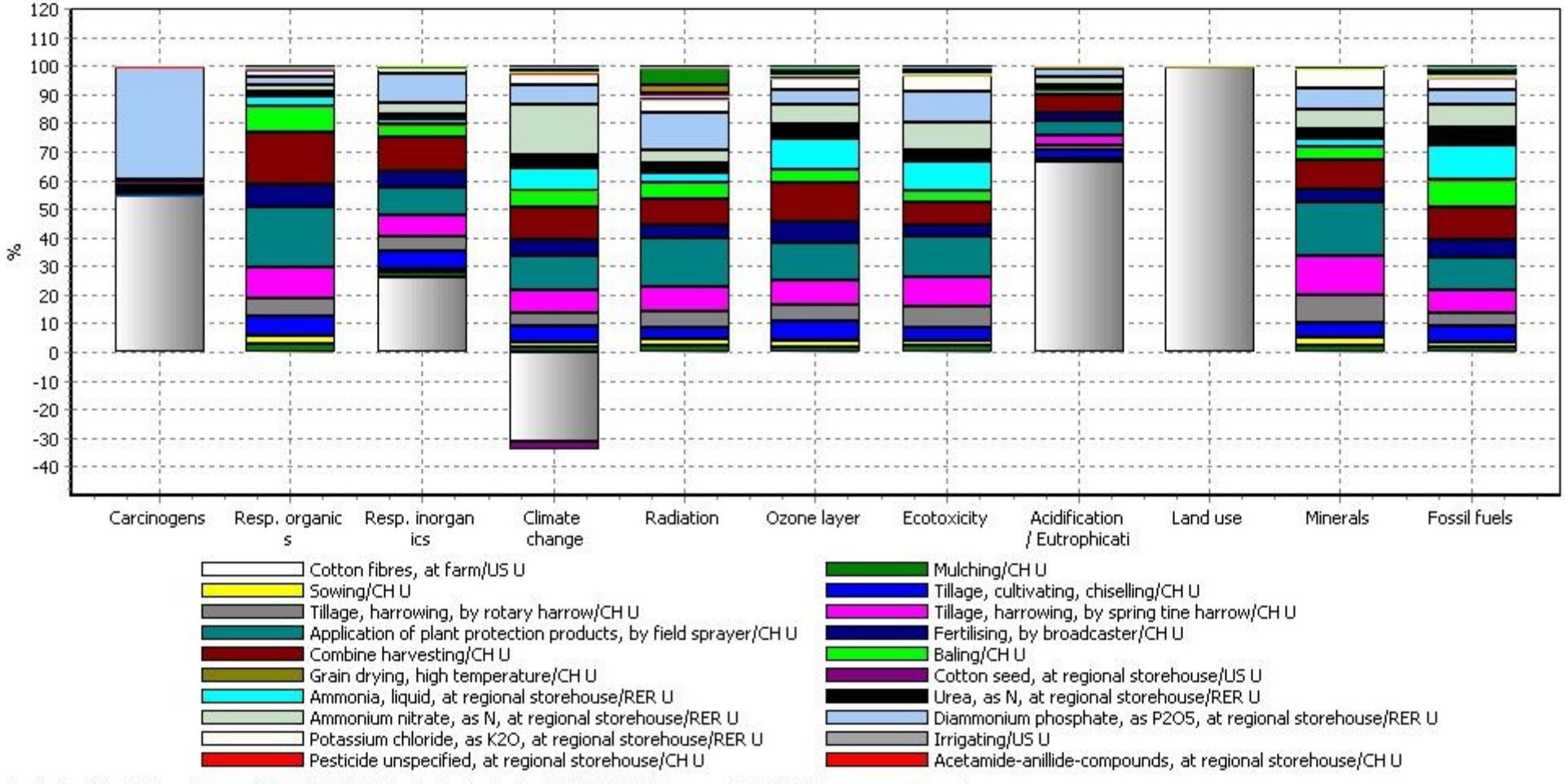
Year	2000	Unit
Energy Use	0.012	Million Btu/pound
Soil Loss	33.2	Pounds soil/pound cotton
Irrigation Water Use	1.5	Thousand gallons/Incremental pound due to irrigation
Net Carbon Emissions	0.5	Pounds carbon/pound cotton
Land	0.002	Acres/pound

(Values are expressed as 5-year centered averages.)

Source: Keystone Center, Keystone CO

Field to Market

Life Cycle Assessment Potential: Multiple Factors



Source: EcoInvent, SimaPro

Emerging Consensus on LCA Framework

- Need for comparable metrics that span sectors, industries and geographies
- Metrics should be grounded in scientific methodologies, namely Life Cycle Assessment
- LCA data (LCI) should be transparent, validated, widely available, inexpensive
- The same LCA data and models should be used by producers, retailers, policymakers, NGOs and consumers
- Sustainability Metrics, Indicators and Indices must be transparent