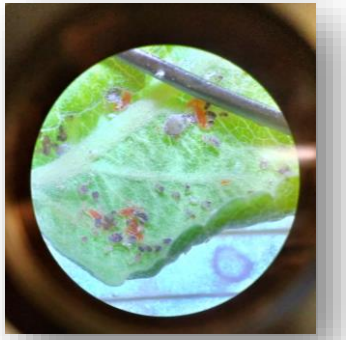
Week 5 Session



Climate-Smart Agriculture and Sustainability

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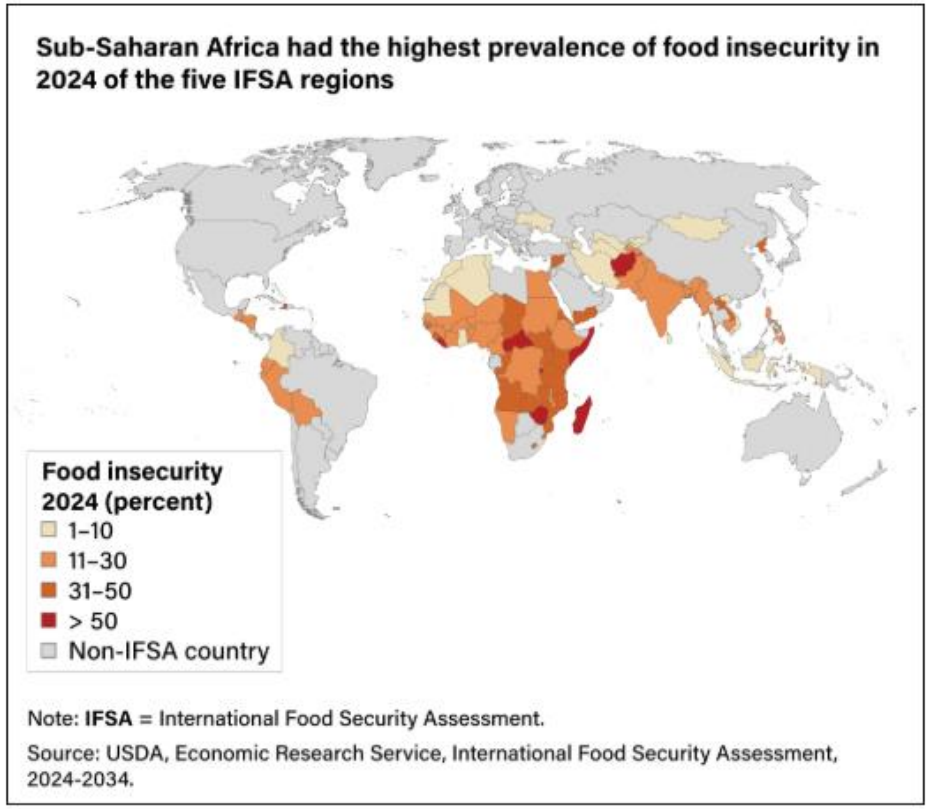
Overview

- **1960's Green Revolution**
- **Global Challenges in Agriculture**
  - Key drivers of climate change
- **What is Climate-Smart Agriculture?**
  - UN Sustainable Development Goals
  - Examples
- **Sustainable Agriculture**
  - **Case Study:** IPM (Integrated Pest Management) in Apple Fruit Production in the Northeast region of the United States



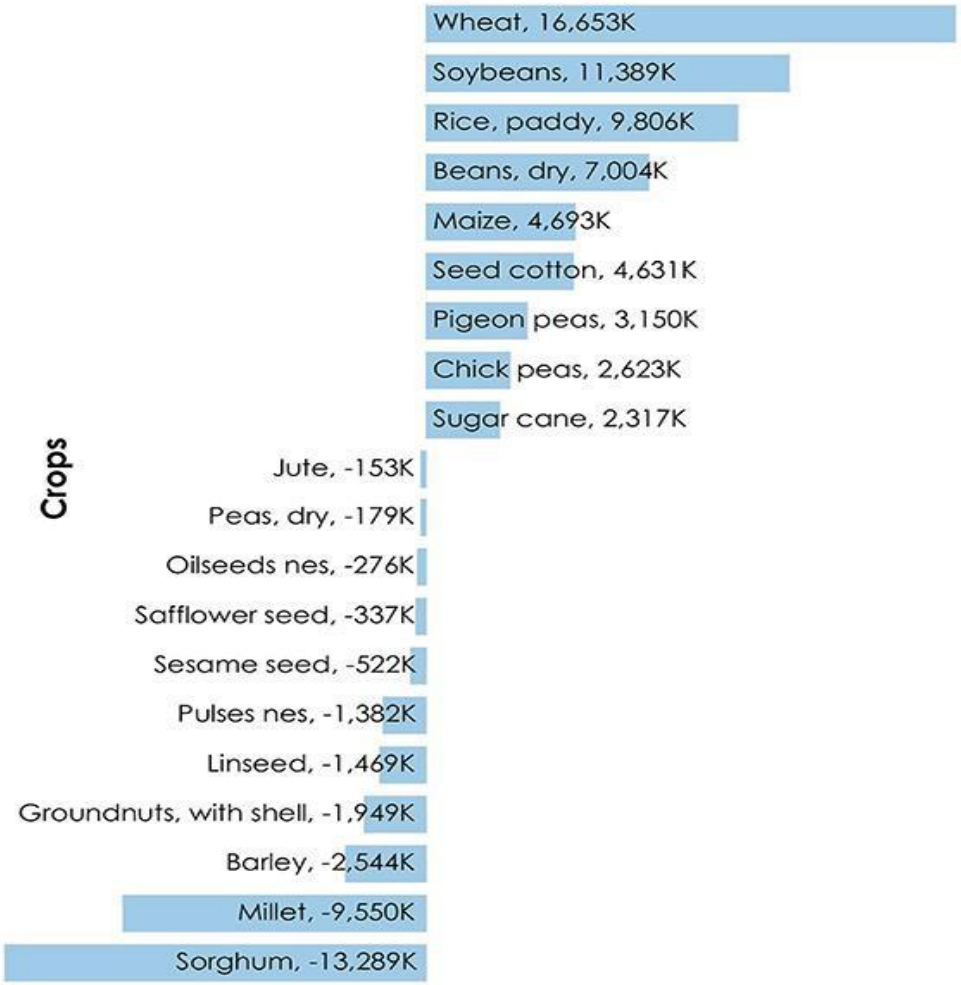
Background: Green Revolution (1943-1970)

- Period of time that reflected the introduction of new technologies in the agricultural sector that aimed to **boost production** and **crop yield outputs** through a series of diversified measures (Ahmad et al., 90)
- **Key Points:**
  - Adoption of high yielding crop varieties (HYV) → wheat, corn, and rice
  - Development of shorter crops that were more responsive to synthetic fertilizers
  - Improved irrigation systems
- Green Revolution had both **positive and negative impacts** in India
  - **Pros:** Shift from importing grains to self sufficiency, short-term yield increases, double cropping in one season, rapid diet diversification
  - **Cons:** Shift to global inputs for wheat and rice, seed patenting, privatization and consolidation of suppliers, adaptation of monoculture for HYV

Norman Borlaug in Mexico with high-yielding wheat varieties.
(Source: Britannica, 2026)

Source: Green Revolution in Pakistan, 2004

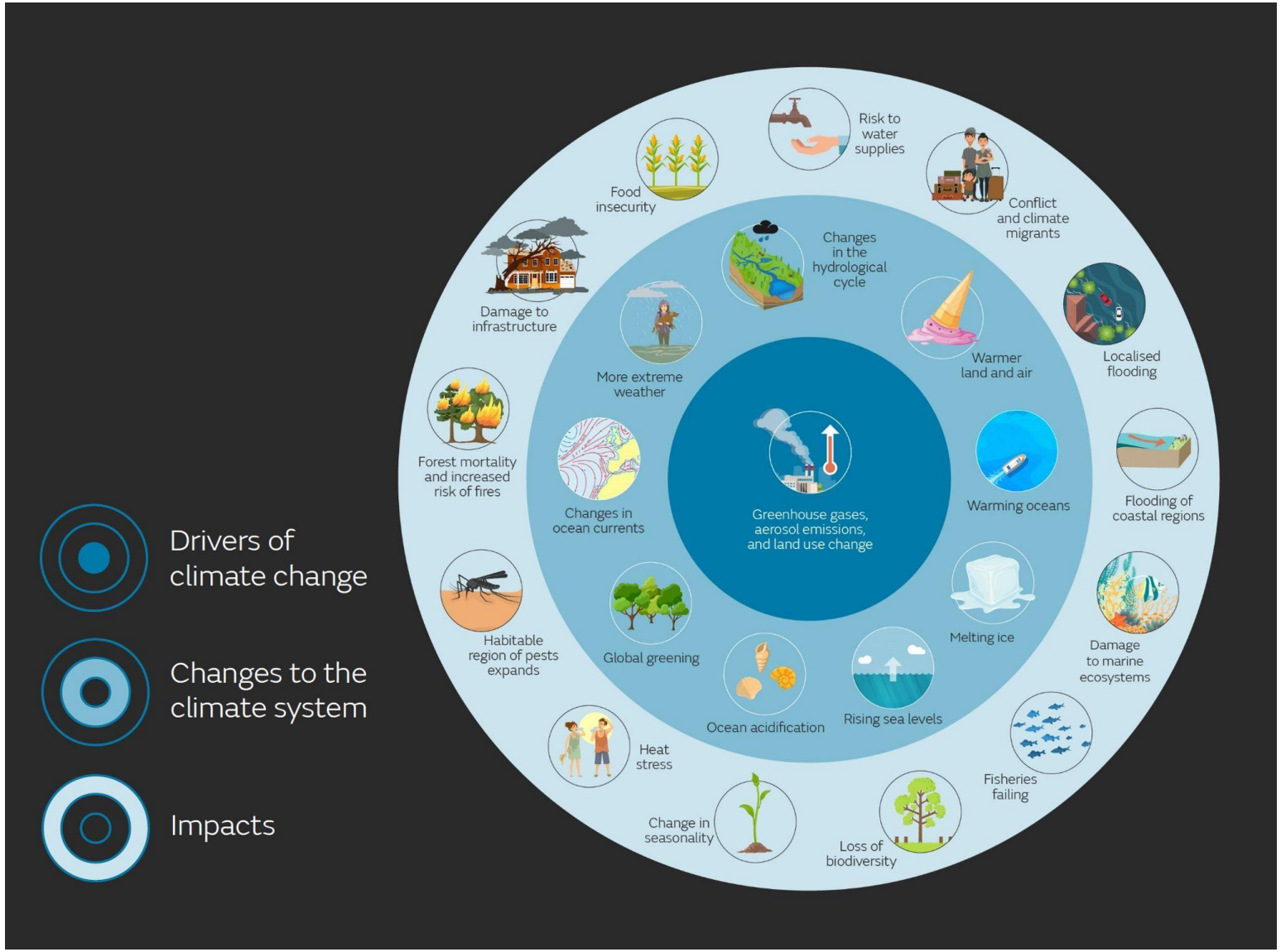
Crops	1961	2018
Wheat	12,927K	29,580K
Soybeans	11K	11,400K
Rice, paddy	34,694K	44,500K
Beans, dry	6,541K	13,546K
Maize	4,507K	9,200K
Seed cotton	7,719K	12,350K
Pigeon peas	2,433K	5,583K
Chick peas	9,276K	11,899K
Sugar cane	2,413K	4,730K
Jute	917K	764K
Peas, dry	1,177K	998K
Oilseeds nes	477K	201K
Safflower seed	440K	103K
Sesame seed	2,252K	1,730K
Pulses nes	3,592K	2,210K
Linseed	1,789K	320K
Groundnuts, with shell	6,889K	4,940K
Barley	3,205K	661K
Millet	18,657K	9,107K
Sorghum	18,249K	4,960K



Changes in area cultivated for traditional and improved crops in India from 1961 to 2018.

Source: (John and Babu, 2021)

Global Challenges in Agriculture- Major Drivers



Source: [Effects of Climate Change]

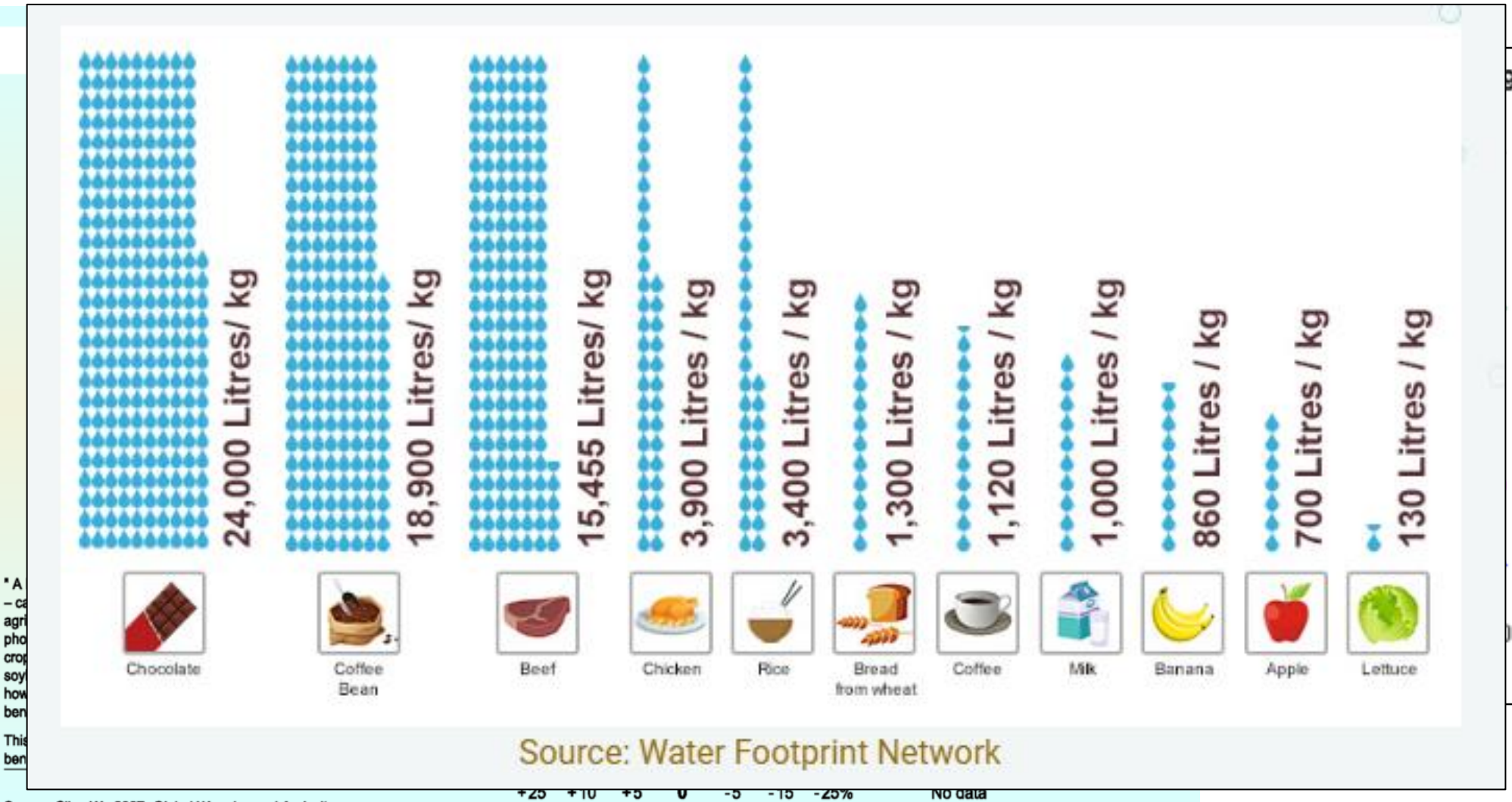
Current Global Challenges in Agriculture- Pesticides

- The use of pesticides and fertilizers in modern agriculture is **inefficient and unsustainable** — less than 10-40% is delivered to targeted crop (Wang et al., 2020)

- **Pesticide residues** can remain in plant tissue (e.g., apples) and cause long-term health issues in humans (cancer, infertility, etc.) (Gomes et al., 2020)

- **Resistance to insecticides** costs the U.S. $10 billion dollars/year in the agriculture sector (Gould et al., 2018)

Current Global Challenges in Agriculture (cont.)



900-2000

Compiled by the Worldwatch Institute from P.H. Gleick (1993) Water in crisis, Oxford University Press.

Source: Cline W., 2007, *Global Warming and Agriculture.*

Climate-Smart Agriculture (CSA)

- Approach to help guide actions to **transform** and **reorient** agricultural systems to effectively and sustainably **support development and food security** under a **changing climate** (FAO)
  - Includes cover crop and livestock production, fisheries, and forest management
- CSA is *not a new form of production or farming practices*
- Seeks to tackle three goals:
  1) **Productivity:** Increase food security by increasing agricultural productivity and incomes
  2) **Adaptation:** Strengthen farmers capacity to adapt to climate change
  3) **Mitigation:** Reduce GHG emissions compared to expected trends

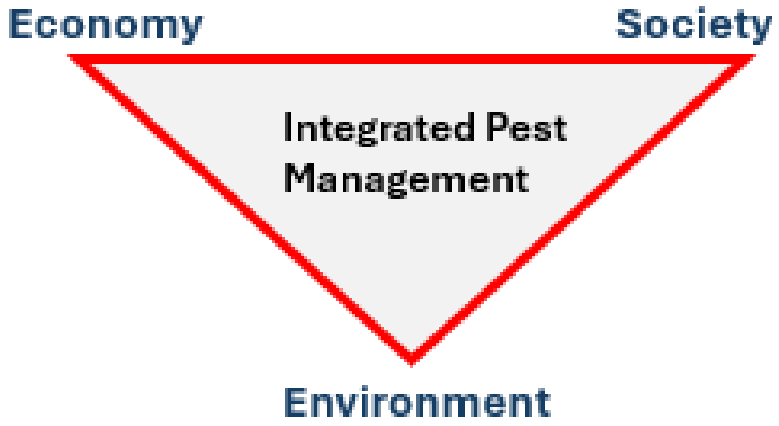
Source: Knowledge on Climate Smart Agriculture

Source: UN Sustainable Development Goals

Sustainable Agriculture

- Encompasses a wide range of practices that are intended to **protect** the environment, **expand** the Earth's natural resource base, and **improve** soil fertility (USDA, 2026)

- Defined by three goals:
  - Enhancing **environmental quality**
  - Sustain **economic viability** of agriculture
  - Enhance the **quality of life** for farm families, farm workers, and communities



7 SUSTAINABLE AGRICULTURE PRACTICES

Agroforestry

Crop Rotation

Cover Crops

Organic Farming

Recycle and compost waste material

IPM Methods

Urban Agriculture

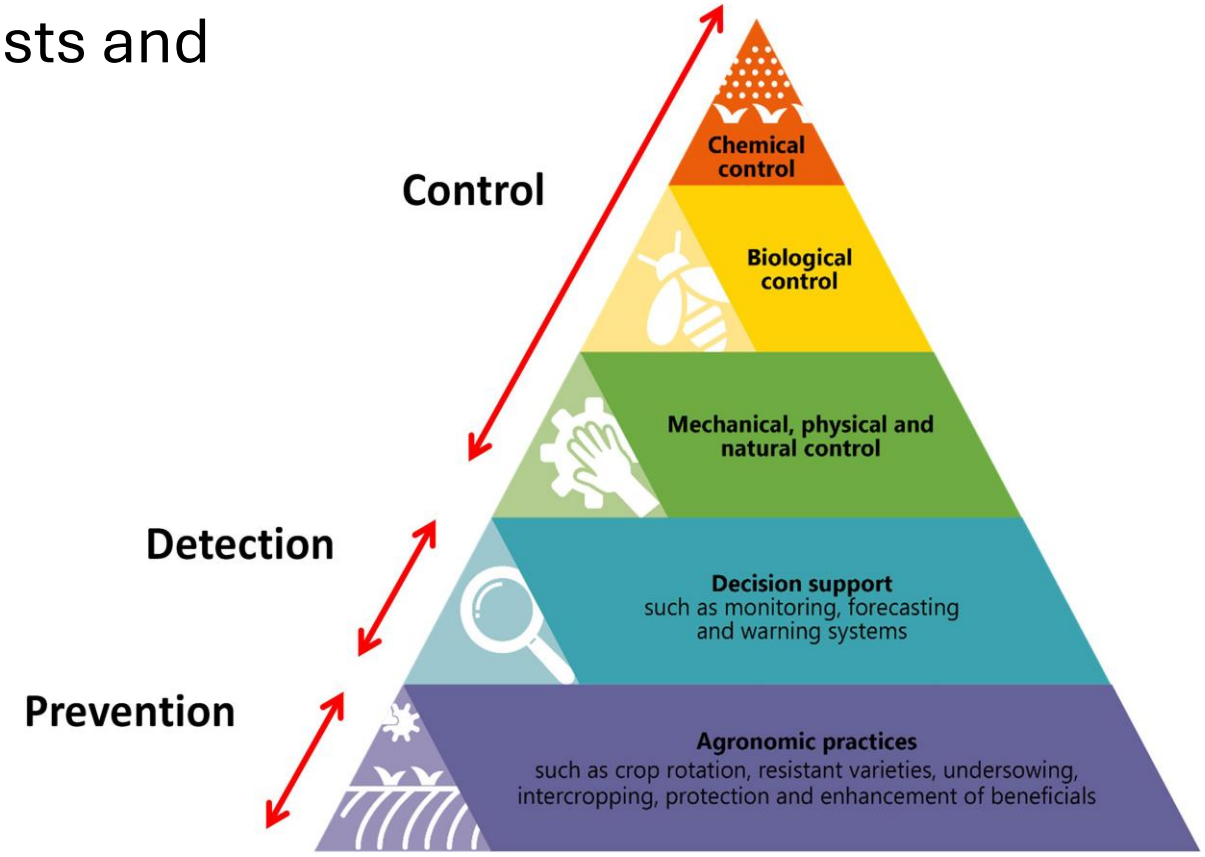
Source: [Sustainable Agriculture: Types, Benefits, Practices and More, 2024]

Climate-Smart *vs.* Sustainable Agriculture

Aspect	Climate-Smart Agriculture	Sustainable Agriculture
Focus	• Address climate change impacts by increasing resilience while working on food security for all	• Environmental stewardship, increasing farm income, and enhancing quality of life for farmers and farm workers
Main Goals	• Mitigate affects of climate change • Adapt to changing conditions • Improve crop productivity	• Maintain ecological balance and conserve natural resources • Larger focus on the social and economic dimensions (i.e. profitability and quality of life)
Scope	• Targeted to the three pillars related to climate (productivity, adaptation, and mitigation)	• Broad- includes soil health, biodiversity, water conservation, reducing chemical inputs, farmer livelihoods, etc.
Key Metrics	• GHG emission reductions, climate resilience, adaptation capacity	• Biodiversity, soil health, economic viability, social equity
Examples	• Agroforestry, planting climate-resilient crop varieties, livestock management	• Crop rotation, cover cropping, IPM, drip irrigation, intercropping

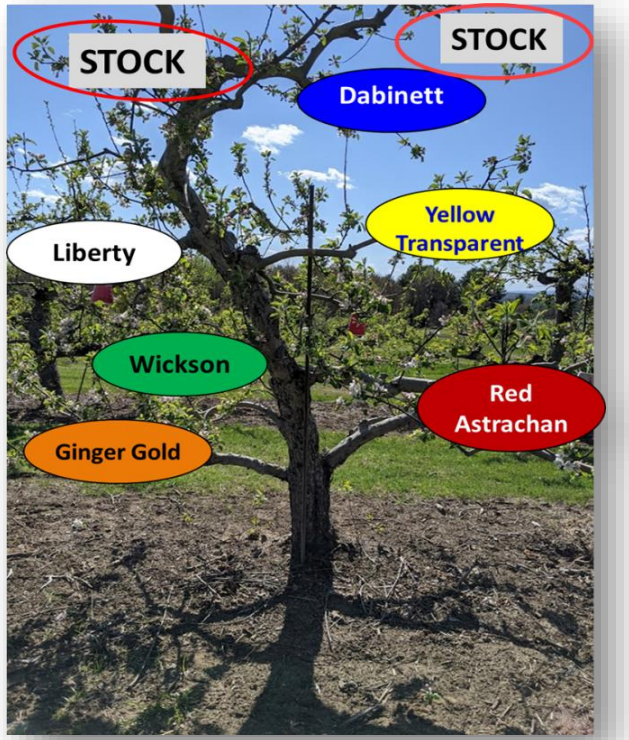
Integrated Pest Management (IPM)

- **IPM:** A decision support system approach to pest control that emphasizes prevention of pests and their damage (USDA and EPA)
- Uses the **pest and host biology** as well as the **environmental monitoring** to respond to pest problems with ecological management tactics
- Combines **cultural** (e.g., crop rotation), **mechanical** (e.g., traps), and **biological** controls (e.g., natural enemies)
- **Monitoring** (i.e., checking your fields) is key to determining if the pest warrants further control
- 'Action' is required if a pest reaches the **economic threshold**



IPM Case Study: Northeast Apple Production in the United States

Thesis Focus: Early-season Host Selection by Insect Herbivores among Six Apple Cultivars



Significance of Apple Production in the U.S.

- Apples (*Malus domestica*) are considered one of the **top tree fruit crops in the U.S.** for local consumption as well as for international export
- According to the USDA (2024), fresh apple production in the U.S. was valued at over **$2.7 billion dollars** and yielded 3.91 million tons of fruit
- In Massachusetts, apples are cultivated on over 1,255 hectares, with **6.4 tons (14,110 lbs.) of this fruit produced in 2022** (USDA, 2023)
- **Agri-tourism and apple picking** are major sources of revenue for small farms across New England (Voigt, 2020)

Using Perennial Trap Cropping as an IPM Tool

- **Trap cropping** is an IPM strategy that involves planting a more attractive or preferred host plant near a main crop to divert pests away from it (Hokkanen 1991)
- Some cultivars are *more attractive* to certain insect pests than others
- **2018:** Perimeter-row apple trees across 10 commercial orchards in Massachusetts were grafted with **6 apple cultivars**

Conclusion

- **Climate change and its associated stresses** (droughts, diseases, pests, etc.) are expected to **decrease agricultural productivity,** particularly in the Global South
- **Sustainable agriculture** seeks to **meet current food needs** while conserving the planet's ability to sustain future generations
- **Climate-Smart Agriculture (CSA)** builds on the concepts and technologies from sustainable agriculture, but focuses on **integrating the unprecedented impacts of climate change**
- **IPM** is an important decision-making tool that farmers can utilize to effectively **manage** insect pest (or disease) damage with the lowest possible risk to humans and the environment