Chapter 9
FOOD &
AGRICULTURE
OUTLINE

• FOOD AND NUTRITION
• KEY FOOD SOURCES
• FARM POLICY
• SOIL
  ❖ WAYS WE USE AND ABUSE SOIL
• AGRICULTURAL RESOURCES
  ❖ WATER
  ❖ FERTILIZER
  ❖ ENERGY
• GENETIC ENGINEERING
• SUSTAINABLE AGRICULTURE
RESOURCE MANAGEMENT

- **NATURAL RESOURCE** – part of the environment to which we attach economic value. Referred to as **ECOSYSTEM CAPITAL**

- **CONSERVATION** - the management or regulation of a resource so that its use doesn’t exceed its renewability.

- **PRESERVATION** – maintenance of resources to ensure their perpetuation without concern for any monetary value.
RENEWABLE vs NONRENEWABLE RESOURCES

- **RENEWABLE RESOURCES** – can be regenerated quickly – within the realm of a human lifespan or human existence.
  - Plants, animals, water, soil, wind

- **NONRENEWABLE RESOURCES** – can NOT be regenerated quickly – formed through slow geologic processes
  - Fossil fuels, minerals, metals
RESOURCE USE

- **CONSUMPTION** – refers to the day-to-day use of resources ie: food, clothing, shelter
  (A fisherman catches fish to feed his family.)

- **PRODUCTION** – refers to the use of resources for profit
  (A fisherman catches fish to sell at a market.)
World food supplies have more than kept up with human population growth over the past two centuries.

- During the past 40 years, population growth has averaged 1.7% per year, while food production increased an average 2.2%.
- There is more than enough food for everyone... if it were distributed equally.
HUNGER AROUND THE WORLD

- Africa – 20-35% of populations are undernourished
- Asia, South America – 5-20% are undernourished
- N.America, Europe, Japan - < 5% are undernourished
CHRONIC HUNGER AND FOOD SECURITY

• FOOD SECURITY - the ability to obtain sufficient food on a daily basis
  ❖ Poverty is the greatest threat to food security – most impoverished people lack food reserves and lack the ability to grow their own food.

• UNDERNOURISHED. Not getting enough calories per day ~ 2200 is average requirement.
ACUTE FOOD SHORTAGES

- **FAMINES** are large-scale food shortages, leading to massive starvation, social disruption, and economic chaos.
  - Mass migrations from impoverished areas to refugee camps to find food and work.
    - Refugee camps are often overcrowded leading to disease, crime, etc.
  - Environmental conditions are immediate trigger to most famines, but armed conflict and political oppression are often underlying causes.
WE NEED THE RIGHT KINDS OF FOOD

• MALNOURISHMENT - nutritional imbalance caused by a lack of specific dietary component
  - 3 Billion people suffer from vitamin, mineral or protein deficiency.
  - Results in illness, reduced mental capacity, developmental abnormality, stunted growth, death
  - THESE DISEASES ARE PREVENTABLE WITH PROPER NUTRITION!
NUTRITIONAL PROBLEMS

• **IRON DEFICIENCY** is the most common dietary imbalance in the world.
  - Leads to **anemia**, insufficient hemoglobin in the blood
  - Increases risk of death from hemorrhage in childbirth and affects development
  - Red meat, eggs, legumes (peas), and green vegetables are all good sources of iron.

• **FOLIC ACID DEFICIENCY** linked to nerve damage such as spina bifida and anencephaly.
NUTRITIONAL PROBLEMS

- **LACK OF IODINE** affects Thyroid gland - leads to “goiter” as well as stunted growth and reduced mental capacity.

- **LACK OF VITAMIN A** affects as many as 140 million children and 350,000 go blind each year. (caused by a diet of mainly starch)
PROTEIN DEFICIENCY DISEASES

- **KWASHIORKOR** - occurs mainly in children whose diet lacks high-quality protein
  - Reddish-orange hair, bloated stomach
- **MARASMUS** - “To Waste Away” - caused by a diet low in protein and calories.
  - Very thin, shrunken
OVERNOURISHMENT

- People in DEVELOPED countries eat too much meat, salt, sugar and saturated fat and not enough fiber, vitamins, and minerals.
- On average, we consume 33% more calories than needed. 62% of Americans are overweight.
- Obesity is spreading around the world as other people adopt Western lifestyles.
- New dietary pyramids recently published.
KEY FOOD SOURCES

- Three crops deliver **majority** of world’s nutrients:  **WHEAT, RICE AND CORN**
  - Potatoes, barley, oats and rye are staples in cool, moist climates. (temperate areas)
  - Cassava, sweet potatoes, and other roots and tubers are staples in warm, wet climates. (tropics)
- Fruits & vegetables although high in fiber, vitamins and minerals make up a small portion of the typical human diet.
MEAT AND DAIRY

- 60% of all meat is raised in developing countries – but they only consume 1/5 of this meat. Developed countries consumed the majority of meat and dairy, however meat consumption in developing countries is rising.

- Modern breeding techniques provide cattle resistant to heat and tropical diseases.

- But creating pastureland from tropical forests and savanna reduces biodiversity and causes conflicts as landless farm workers are forced into poverty conditions.
FEEDLOTS

- CONCENTRATED ANIMAL FEEDING OPERATIONS - in North America animals are quickly fattened on grain in FEEDLOTS
  - Local air and water pollution caused by untreated waste especially nitrogen wastes and fecal bacteria.
  - Animal wastes are often stored in “lagoons” but can be unintentionally released causing contamination of soil, water and food.
  - High density of animals requires constant use of antibiotics, leading to antibiotic resistance in microbes.
  - Hormones used to increase growth rate
SEAFOOD

- Seafood is an important protein source. (15%)
- Subsidies are again heavily used to benefit the fishing industry
- Since 1989, 13 of the 17 major fisheries have declined or are commercially unsustainable.
- If current practices continue, the world’s fisheries will be exhausted by 2050.
- “BY-CATCH” large numbers of birds, turtles, and other species caught unintentionally.
  - Purse-seine nets
  - Trawlers
  - Longlines
  - Drift & Gill nets
4 MAJOR OVERFISHING PRACTICES

1. GILL or DRIFT NET
2. LONGLINES
3. PURSE SEINE NETS
4. TRAWLERS
4 MAJOR OVERFISHING PRACTICES

1. GILL or DRIFT NET – long nets that float in the ocean catching anything that swims into it.

2. LONGLINES – miles or fishing line with hundreds of hooks

3. PURSE SEINE NETS – nets used to encircle schools of fish – mile or more in circumference

4. TRAWLERS- nets pulled through the water, usually on or near the bottom of the ocean
TED - TURTLE EXCLUDER DEVICES

A TED is a trap door with bars. Small animals like shrimp slip through the bars and are caught in the end of the trawl. Large animals like turtles and sharks hit the bars escape through an opening.
- **AQUACULTURE** - raising aquatic species in pens. Is increasing the share of the world’s seafood.

- Aquaculture supplies food, **BUT** it
  - uses wild populations to stock and feed captive populations
  - destroys mangrove forests and wetlands used as nurseries for all marine species
  - allows the spread of disease (high density)
  - releases large quantities of feces, antibiotics and other pollutants into waterways
• **AQUACULTURE**
  - **FISH** - tilapia and catfish in inland ponds
  - **CRUSTACEANS & MOLLUSKS** – shrimp, lobster, oysters, clams
  - **FISH RANCHING** – trout and salmon are raised to a survivable size and released.
  - **ALGAE** are also raised for harvest
  - **POLYCULTURE** of mixed species of herbivores or filter feeders can help reduce pollutants released in monocultures.
FARM POLICY

- **SUBSIDY** - a sum of money granted by a government to assist an industry or business so that the price of a commodity or service may remain low or competitive.

- Farm subsidies in many countries are protected by powerful political and economic interests.
  - Agricultural subsidies encourage surpluses and allow American farmers to sell products overseas at prices below production costs.
  - Most aid goes to just a few crops such as corn, wheat, soybeans, rice and cotton.
  - Aid encourages intensive farming of land which encourages erosion.
FARM POLICY

• Farm subsidies cont....
  ❖ US grown crops are sold cheaper than local produce – this creates a dependence on cheap foreign crops and reduces local farming and production.
  ❖ 2005 the World Trade Organization ruled US subsidies to be illegal because they were causing food prices to be distorted.
SOIL: A RENEWABLE RESOURCE???

- SOIL - a complex mixture of weathered minerals, partially decomposed organic materials, and a host of living organisms that sustain life
- Soil types worldwide due to different parent material, time, topography, climate, & organisms
- Can be replenished and renewed. However, in many places we are using it faster than it can be replaced.
  - Optimum accumulation rate is 1 mm/yr.
  - Worst erosion rate is 25 mm/yr.
- Young soils contain nutrients
- Old soils are “leached” of their nutrients
SOIL COMPOSITION
PARTICLE SIZE & SOIL CHARACTERISTICS.

- Spaces between soil particles give sandy soil good drainage and allows aeration, but sandy soils can easily dry out.
- Tight packing of small particles in clay soils makes them less permeable to air and water.

- **HUMUS** – dark-colored organic material remaining after decomposition of plant and animal material. Gives soil a spongy texture which holds water and nutrients.
- **LOAM** – a soil type that is fairly balanced in composition and contains humus.
CHEMICAL PROPERTIES OF SOIL

- pH range between 6 & 7 for most plants
  - At low pH metals (aluminum, iron, boron, manganese) are more available for plant use. **Aluminum can be toxic**
  - To make soil more acidic (decrease pH) add sulfur or aluminum sulfate
  - To make soil more basic (increase pH) add lime (calcium carbonate)
Nitrogen and phosphorus are limiting factors and should be tested for. (apply fertilizer as needed)

Salinity – salt content of irrigated areas

Micronutrients such as iron, manganese, magnesium, selenium

Amount of Humus – this influences nutrient abundance, porosity, water holding capacity, aeration of soil
PHYSICAL PROPERTIES OF SOIL

• **Soil color** indicates nutrient level:
  - Dark brown/black is high in humus and organic material
  - Red indicates high iron content and low nutrient content

• **Porosity** – % of space between soil particles

• **Permeability** – rate at which water and air move through the soil
  - Porosity & Permeability have an INDIRECT relationship
The image illustrates the relationship between pore spaces and permeability in different types of soil. The diagram shows:

- **No pore spaces**: Non-porous, non-permeable.
- **Unconnected pore spaces**: Porous, non-permeable.
- **Connected pore spaces**: Porous, permeable.

The permeability of soils is determined by the size of the pore spaces.沙土 (sand) with a diameter of 0.05–2 mm has high permeability, making it suitable for water movement. 可蒙土 (silt) with a diameter of 0.002–0.05 mm has moderate permeability. 蒙土 (clay) with a diameter less than 0.002 mm has low permeability, making it less suitable for water movement.

Water flow is depicted as follows:
- **Sand**: High permeability, allowing water to flow freely.
- **Silt**: Moderate permeability, water flow is more restricted.
- **Clay**: Low permeability, water flow is significantly restricted.

The diagram visually represents these concepts, emphasizing the importance of pore structure in determining soil permeability.
SOIL COMPOSITION

HEAVY SOILS - High in clay content

LIGHT SOILS – Composed mostly of sand or silt

MOST SOILS HAVE A COMBINATION OF SAND, SILT and CLAY

ORGANIC CONTENT VARIES FROM 0% IN PURE SAND/SILT/CLAY TO CLOSE TO 100% IN PEAT.
SOIL TEXTURE DIAGRAM
DETERMINING SOIL TYPE

- What type of soil is composed of....
  - 50% clay, 30% sand, 20% silt = ________
  - 20% clay, 40% sand, 40% silt = ________
  - 10% clay, 20% sand, 70% silt = ________

- Farmers prefer Sandy Loam soil what do they need?
  - ____% clay, _____% sand, _____% silt
SOIL ORGANISMS

- Activity of organisms living in soil helps create structure, fertility, and cultivation suitability.
- **MICORRHIZAL SYMBIOSIS** - an symbiosis between roots of plants and certain fungi. Plant feeds the fungus and the fungus provides water and inorganic nutrients to the plant to enable it to grow better.
- **Bacteria** and **Fungus** act as decomposers
- **Algae** are present on the surface of many soils
- **Worms** aid in aeration of soils
- **Insects, rodents, snakes**, dig and aerate soils
- **Snails, millipedes, insects** feed on debris
SOIL HORIZONS

Soils are stratified into horizontal layers called **SOIL HORIZONS**.

Horizons taken together make up a **SOIL PROFILE**.

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<th>SOIL HORIZONS</th>
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| **A** | Topsoil  
organic matter (humus), living organisms, inorganic minerals |
| **E** | Zone of leaching  
dissolved or suspended materials move downward |
| **B** | Subsoil  
accumulation of iron, aluminum, humic compounds, and clay leached down from the A and E horizons |
| **C** | Regolith  
partially broken down inorganic minerals |
| **Bedrock** |
SOIL HORIZONS - OAEBC

- **O HORIZON** (Organic layer)
  - Leaf litter, partially decomposed organisms

- **A HORIZON** (Topsoil) – rich with humus
  - Mineral particles mixed with organic material

- **E HORIZON** (Leached) - ELUVIATED
  - Depleted of soluble nutrients via leaching

- **B HORIZON** (Subsoil) - ILLUVIATION
  - Often dense texture from accumulating nutrients leached from A&E horizons.

- **C HORIZON or REGOLITH** (Parent Material)
  - Weathered Rock fragments with little organic material
12 SOIL TYPES

- Soils are classified according to structure and composition

- **SPODOSOLS** – form under coniferous forests, generally acidic and poor for farming

- **ALFISOLS** – form under temperate deciduous forests, high nutrient content. Leaching takes place but leaf litter is replaced each year

- **MOLLISOLS** – found in temperate grasslands, fertile, thick topsoils, thick layer of humus, little leaching due to dry season

- **ARIDISOLS** – form in arid regions – deserts, low in organic matter, little leaching (dry)
- **HISTOSOLS** – form in waterlogged areas, incomplete decay of organic material (peat)
- **OXISOLS & ULTISOLS** – form in hot, wet areas, low in nutrients due to high leaching from rainfall, low in leaf litter – high rates of decomposition
- **ANDISOLS** – formed in volcanic ash
- **VERTISOLS** – clay-rich soils that shrink and swell with changes in moisture
- **INCEPTISOLS** – freely draining soils that exhibit minimal horizon development
- **ENTISOLS** - soils that only have an A horizon
- **GELISOLS** - are soils of very cold climates that contain permafrost
NAME THE DOMINANT SOIL TYPE FOR EACH NUMBER
HINT: think about your biomes & plate tectonics!
Spodosols, Alfisols, Mollisols, Aridisols, Oxisols, Ultisols, Andisols, Vertisols, Gelisols,
WAYS WE USE AND ABUSE SOIL

- Approximately 12.5% of the earth’s land area is currently in agricultural production.
  - Up to four times as much could potentially be converted to agricultural use.
    - Much of this additional land suffers from constraints such as steep slope or poor drainage.
- Global climate change could alter weather patterns and flood coastal areas so that world food production could be seriously reduced.
ARABLE LAND UNEVENLY DISTRIBUTED

- North America and Europe are particularly well suited to growing while some other parts of the world lack suitable soil, topography and water.

- Available cropland is shrinking.
  - Exceptions are South America and Oceania, where forests are being converted to farms

- Gains in agricultural production have come from increased fertilization, pesticides and irrigation rather than more land. **Productivity has increased over time.**
SOIL PROBLEMS - LAND DEGRADATION

- 3 million ha of cropland ruined due to erosion
- 4 million ha transformed into deserts
- 8 million ha converted to non-agricultural uses.

Remember.... ha stands for hectare, which is 10,000 m\(^2\) or about 2.5 acres. (1 ha is roughly 1.5 football fields)

- Over the past 50 years, 1.9 billion ha of agricultural land has been degraded.
SOIL PROBLEMS - LAND DEGRADATION

- Definitions of degradation are based on both biological productivity and expectations of what land should be like.
  - Generally, land is considered degraded when soil is poor or eroded, run-off is contaminated, or biodiversity is diminished.
  - Water and wind are the driving forces for vast majority of soil degradation.
EROSION

- Erosion is a natural process, resulting in the movement of soil from one place to another.
- Erosion usually results in the loss of topsoil, limiting plant growth and reducing soil fertility.
- Erosion results in sediment flowing into rivers and lakes, siltation of reservoirs, and smothering of wetlands and coral reefs. Decreasing water quality and increasing turbidity.
- Contaminated soils may cause eutrophication (fertilizers) and animal death (pesticides) may occur.
TYPES OF WATER EROSION

- **SHEET EROSION** – moves water down a slope and erodes topsoil evenly

- **RILL EROSION** - small rivulets of running water cut small channels in the soil

- **GULLY EROSION** - rills enlarge to form bigger channels, usually on steep slopes. Gullies are too large to be removed by normal tillage

- **STREAMBANK EROSION** - washing away of soil from banks of streams & rivers. Cattle grazing in riparian areas is usually the cause
MECHANISMS OF WIND EROSION

- Wind erosion is most severe in dry climate and on flat land.
- Intensive farming practices responsible for erosion:
  - Row crops leave soil exposed.
  - Weed free-fields
  - Removal of windbreaks
  - No crop-rotation or resting periods for fields
  - Continued monoculture cropping can increase soil loss tenfold.
DESERTIFICATION

- DESERTIFICATION - conversion of productive land to desert due to climate, overgrazing and deforestation

- Rangelands and pastures are highly susceptible (overgrazing, soil degradation).

- Africa and China are of particular concern.
  - Rapid population growth and poverty create unsustainable pressures.
  - Removal of trees for fodder and firewood triggers climate change that spreads desertification.
OTHER AGRICULTURAL RESOURCES

- WATER
  - Agriculture accounts for largest single share of global water use.
    - Much irrigation water lost to seepage and evaporation
    - In some countries, low cost (subsidy) encourages over-use of water.
  
- WATERLOGGING – plant roots die (lack of oxygen) when soil is saturated with water

- SALINIZATION - over time, mineral salts collect in topsoil when water evaporates and stunts plant growth, reducing yield
FERTILIZER

- Lack of nitrogen, potassium, and phosphorus often limits plant growth.
  - Adding nutrients via fertilizer usually stimulates growth and increases crop yields.
    - 1950 - average of 20 kg/ha fertilizer used
    - 1990 - average of 91 kg/ha fertilizer used
  - Overuse causes EUTROPHICATION.
  - Manure and nitrogen-fixing bacteria are alternative methods of replenishing soil nutrients.
  - Fertilizer use could increase crops in Africa.
ENERGY

- Farming in industrialized countries is highly energy-intensive.
  - Between 1920-1980, energy use rose directly with mechanization of agriculture, and indirectly with synthetic fertilizers.
  - Altogether, U.S. food system consumes 16% of total energy use.
    - Most foods require more energy to produce, process, and transport than we get from eating them. Eating locally grown foods has less environmental impact.
GREEN REVOLUTION

- DEVELOPMENT OF HIGH-YIELD CROP PLANTS through years of selective breeding/cultivation
  - Corn yields jumped from 25 bushels per acre to 130 per acre in last century.
    - Most of gain accomplished through conventional plant breeding
- GREEN REVOLUTION started by Norm Borlaug. Dwarf, high yielding wheat and rice grown around the world. Borlaug won Nobel Peace Prize
GREEN REVOLUTION

- Green revolution plants require high amounts of water, fertilizers and pest protection. **If these are lacking, modern crops may not produce as well as traditional crops.** Poor farmers may be left out of the green revolution.
- Crops of green revolution grow in temperate climates. Efforts underway to create new crops for tropical climates.
GENETIC ENGINEERING - removes DNA from one organism and splices it into the chromosomes of another. Produces TRANSGENIC or GENETICALLY MODIFIED ORGANISMS (GMOs) with new traits.

**POSITIVES OF GMO’S**

- Can produce crops with pest-resistance and wider tolerance levels to frost, drought, low nutrient soils, salty soils, etc.
- Can improve protein/vitamin content of crops
- Can incorporate oral vaccines into foods such as bananas for use in developing nations
- Animals can be modified to grow faster or produce pharmaceuticals in their milk.
POSITIVES OF GMO’S

❖ Crops are modified to be resistant to herbicides such as “Roundup”. Kills weeds but crops are unaffected.

❖ Golden Rice has been modified to contain vitamin A – beneficial in developing regions to prevent blindness.

❖ Animals (livestock) have been modified to grow quicker with less food.
NEGATIVES OF GMO’S

- Opponents worry that
  - Little is known about long-term effects on people and the environment
  - GMOs might produce superweeds resistant to pesticides/herbicides.
  - Native biodiversity may be reduced.
  - Technology may only be available to the rich, making family farms uncompetitive and driving poor nations further into poverty.
  - Ethics about patenting new living organisms
  - 60% of processed food in the U.S. contains GMOs.
Biotechnologists have recently created plants containing genes for endogenous insecticides. A gene from the bacterium *Bacillus thuringiensis* (Bt) makes toxins that are lethal to butterflies and beetles. These genes have been transferred into corn, potatoes and cotton. Reduces pesticide use and increases yield.

Concern has arisen over several points.
- Spread of genes into wild populations leading to resistance in pests
- Effect on non-target species
IS GENETIC ENGINEERING SAFE?

• Environmental and consumer groups have campaigned against transgenic organisms.
  ❖ “Frankenfoods”
  ❖ European nations have bans on GMOs.

• U.S. Food and Drug Administration recently passed legislation requiring the labeling of foods containing GMOs.
IS GENETIC ENGINEERING SAFE?

• GMOs tested so far do not survive well in the wild and are no more invasive than unmodified plants.
• Worry that genetically modified animals will escape captivity and outcompete their wild relatives. (Salmon with added growth hormone gene grow 7X faster than their wild counterparts.)
• Should err on the side of safety?
• Will GMOs help feed the world or lead to more economic disparity?
SUSTAINABLE AGRICULTURE attempts to produce food and fiber on a sustainable basis while repairing the damage caused by prior destructive practices.

SOIL CONSERVATION/MANAGING TOPOGRAPHY

- **CONTOUR PLOWING** - plowing across a slope to slow flow of water
- **STRIP FARMING** - planting different crops in alternating strips along land contours
- **TERRACING** - shaping land to create level shelves of earth to hold water and soil
- Plant **PERENNIAL** species.
SUSTAINABLE AGRICULTURE
SUSTAINABLE AGRICULTURE

SOIL CONSERVATION/MANAGING TOPOGRAPHY

- **CROP ROTATION** – grow different crops in the same field at different times. Reduces erosion & pests – plant **LEGUMES** in between crops to fix nitrogen

- **SHELTER BELTS** – rows of trees to prevent wind erosion

- **ALLEY CROPPING** or **AGROFORESTRY** - planting strips of trees between crops

- **MULCH** – place over soil to prevent erosion and add to humus as it decays

- **FALLOW FIELDS** – allow the field to be covered by native plants without crops
SOIL CONSERVATION

PROVIDING GROUND COVER – “COVER CROPS”

- Annual row crops cause highest rates of erosion because they leave soil bare for much of the year.
  - Plant cover crops such as clover, rye or alfalfa after harvest.
  - GREEN MANURE - Leave crop residue after harvest or turn cover crops into soil
  - Interplant two different crops in the same field. Harvest one; the other is left to hold the soil. Double harvests are an advantage as well.
SOIL CONSERVATION

- **TILLAGE** – the plowing of land to turn soil to plant seeds

- **REDUCED TILLAGE** is beneficial:
  - **MINIMUM TILLAGE** - reducing number of times soil is disturbed
  - **CONSERV-TILLAGE** – cuts a groove for seeds & leaves the roots of prior crops to prevent erosion,
  - **NO-TILLAGE** - drilling holes (furrows) in the ground for seeds.

- **DISADVANTAGE**: Reduced tillage leaves plant matter behind which promotes pests/weeds
LOW INPUT SUSTAINABLE AGRICULTURE

- Small scale, low input agriculture
- No synthetic chemicals
- Raising cows on pasture grass rather than grain
- No antibiotics
- Typically produces smaller yield, but production costs are lower and prices are higher so net gain is higher
- Preserves rural culture better than factory farms

CONSUMERS’ CHOICES ARE IMPORTANT

- Vegetarian/organic diet reduces env. impact.
- **LOCAVORE** - person who eats locally grown, seasonal food.