Chapter 11 – Producing enough food for the world

Case Study – Food for China

This case study highlights the problem of food supply in developing countries. As countries go through the demographic transition (see chapter 4) they become larger consumers of meat. Since each calorie of meat requires more land than each calorie of plant food, this presents an issue for developing countries.

Can we feed the world?

About 11% of the world's land is in use fro agriculture. Humans continue to alter land to make it arable – as the world's population increases we will have to make choices about how to alter that land and which land to alter. Certainly a key for the future is to increase production per unit area.

How we Starve

There are two main types nutrition issues, undernourishment (not enough food) and malnourishment (deficiency of one or more nutrients such a s protein or a particular vitamin or mineral).

What we eat and what we grow

Crops

Only 150 species have been cultivated, most of the world's food is supplied by only 14 species: wheat, rice, maize, potatoes, sweet potatoes, manioc, sugarcane, sugarbeet, common beans, soy beans, barley, sorghum, coconuts, bananas. **Fig. 11.8** p. 189 shows where the top three are grown. Some crops are **forage**, which are grown for animals to eat.

Crops can be classified as **cash crops**, to be sold in a large market (and not always food, consider tobacco and cotton) or **subsistence crops**, which are used directly by the farmer or sold locally.

Livestock

The major domestic animals are **ruminants** which have a four chambered stomach including symbiotic bacteria that help digest the high cellulose content of plants. Mainly cattle, sheep and goats. These animals are maintained on **pasture**, land plowed and planted to feed the animals, and **rangeland**, which is used to feed the animals without plowing and planting. In the US, much rangeland is managed by the **Bureau of Land Management (BLM).**

Aquaculture

Production of food from aquatic environments – usually applied to animal species. The main example is growing of fish in rice ponds. **Mariculture** is aquaculture in the ocean, mainly it currently involves rafts growing species such as oysters and mussels.

An Ecological Perspective on Agriculture

Farming creates an **agroecosystem** which differs from normal ecosystems by: (1) stopping ecological succession (see chapter 9) by weeding and planting on cleared land; (2) planting a **monoculture**, or only one species in a field; (3) crops are planted in neat, regular rows, this makes it easy for pests to hurt the plants; (4) food chains are greatly simplified; (5) plowing is unlike any natural process.

One way to lessen the effects of monoculture is **crop rotation**, or growing different crops in different fields year after year. This means that nutrients will not be depleted as much as if only one crop was grown every year.

Limiting Factors

"An agricultural limiting factor is the single requirement for growth that is available in the least supply in comparison to the need of the crop." Usually this is a macronutrient such as nitrogen or phosphorous. Some micronutrients could be molybdenum, copper, zinc, manganese, iron, boron, and chlorine. There is not always one limiting nutrient due to synergistic effects (ex. Increasing nitrogen might promote enzymes that could increase intake of phosphorous).

The Future of Agriculture [Fig 11.12, p.206]

Demand-based agriculture is based on highly mechanized farming and a high demand for resources. **Resource-based agriculture** is based on conservation, production is limited by the availability of resources. Organic farming is a third approach describe later in the chapter.

Increasing Yield per Acre

The Green revolution began following World War II, the result was the development of crop strains with higher yields, disease resistance. However these strains required increase fertilization and irrigation – carrying new environmental impacts.

Drip irrigation could improve crop yield by carefully supplying crops with the proper amount of water while also decreasing water consumption. **Hydroponics** could use fertilized water directly without requiring arable land.

[missing – Traditional Farming Methods – p 208]

Organic Farming

Defined by three qualities: more like natural ecosystems than monoculture; minimizes negative environmental impacts; the resulting food contains no artifical compounds (especially pesticides on plants and hormones in livestock).

Alternatives to monoculture

Problem: farmers use climate prediction to choose seed varieties to plant – when they are wrong, productivity can be very low. Alternatives: plant a mix of crops in a field – smaller yield but smaller risk; carefully suiting crop planting to land use (some places are better suited to different kinds of crops **[figure 11.15. p 210]**

Eating Lower on the food chain

Why eat lower ont eh food chain? The second law of thermodynamics says that useful energy is always lost in transformation. Trophic level efficiency is less thatn 10% - so humans can use land more wisely by eating plants, rather than by feeding those plant to animals and eating animals (which would require 10 times more land).

Counterarguments: some land that is good for forage would be terrible for crops; food is more htan just calories – animals are an important source of protein and minerals; domestica animals often have other purposes uch as plowing and excrement used for fertilizer and fuel.

Genetically modified food

Genetically modified crops (GMCs) offer both promise and controversy. Three practices: faster development of hybrids; introduction of the terminator gene; cross species gene transfer. Some goals include better nitrogen fixation, tolerance to drought, heat, cold, soils.

Climate change and Agriculture

Although some areas may have improved crop yield, worldwide climate change is more likely to decrease than increase crop yield. The areas of the world with the best crop soils also have the best climate. Climate change could also effect evapotranspiration patterns, impacting irrigation water supplies.

Optimum Environmental Conditions

The growth of particular crops depend on a combination of environmental factors including rainfall, temperature, and soil type. This can be affected by irrigation (like California's central valley) and application of fertilizer. But some crop growth might be heavily effected by global warming (see chap 21.).

11% of Earth's surface is considered suitable for plant crop (**arable**). 19% of US is arable, over 80% in production, 20% of these considered impacted by urban development. About 79% of wetland destruction is due to agriculture.

World Food Supply

"Today, sufficient food is produced to provide adequate calories for the entire human population, but distribution is uneven and inequitable."

Limits to Food Production

(1) Only some lands can be used for agriculture

(2) many crops have reached limit of benefit from fertilizer

(3) climatic change (global warming) is more likely to decrease yield than to increase it. Crop production is expected to move northward (Canada and Russia) where soils are not as well suited to crop growth.

Ways to Increase the food Supply

(1) **Improved irrigation** – especially drip irrigation, which involves underground pipes slowly putting water into the soil, rather than soaking the surface and creating runoff.

(2) Increasing the amount of Agricultural land – **hydroponics** is the growing of plants in nutrient enriched water, therefore the soil type is not an issue. This can also be done inside a greenhouse, which decreases the effects of climates.

(3) Eating lower on the food chain – Since the second law of thermodynamics shows us that energy is lost to heat in conversion, it is logical that an acre of land can support more humans if they eat plant than if they eat animals that feed on those plants (about 90% more). HOWEVER, (1) "land too poor for crops can make excellent rangeland." (2) animals provide the major source of protein in developed countries. (3) domestic animals can serve other purposes; beasts of burden, wool, leather.

(4) Modification of food distribution

CHAPTER 12 – EFFECTS OF AGRICULTURE ON THE ENVIRONMENT

[missing – case study]

How Agriculture Changes the Environment

There are both primary (on-site) and secondary (off-site) effects of agriculture. These effects can also be classified as:

Local – erosion of soils, loss of soils, increase in stream sediment

Regional – desertification, pollution, increased sediment in large rivers and estuaries

Global – climate change, chemical cycling effects

"Major environmental problems that result from agriculture include deforestation, desertification, soil erosion, overgrazing, degradation of water resources, salinization, accumulation of tokic metals, accumulation of toxic organic compounds, and water pollution including eutrophication."

Our Eroding Soils

Before farmed, soil generally has a high organic content, but since the plants grown on agriculture land are cleared, few nutrients are left behind to replenish the soil, also plowing increases erosion and leaching, which decrease nutrient content. Two kinds of fertilizer are used to combat this problem: traditionally organic fertilizers such as manure are used. Industry can now create nitrogen fertilizers using electricity to fix nitrogen and by mining phosphorous (see chapter 4).

When land is cleared soil begins to lose its fertility. Once the cover is lost it is exposed directly to wind and water which erode the soil. Nutrients are also **leached** from the soil when water flows through it. Plowing turns the soil over in order to increase production, this brings nutrients up from the zone of accumulation [Fig 12.2 p. 220] to the top of the soil. It also exposes land to the effects of erosion and leaching. 90% of US agricultural land is not using land conservation methods.

Where Eroded Soil Goes - Sediment

Much of the soil eroded from farms ends up in waterways as sediment. Sediments fill in otherwise productive waters destroying some fisheries. In tropical waters, sediments can destroy choral reefs. Nitrates and ammonia can cause eutrophication.

Making Soils Sustainable

Contour plowing – plowing perpendicular to the slope, whis way water does not rush down the furrows in downhill areas. This has recently been the most effective method to reduce soil erosion.

Fall plowing: multiculture: strip cropping: terracing: crop rotation.

No-till agriculture – not plowing, using herbicides to keep down weeds, Stema and roots are left behind.

Controlling Pests

Pests are undesirable competitors, parasites or predators. Pests account for 30% loss of potential harvest and 10% loss of harvested crop. Pre-harvest loss is due to weeds, diseases, and herbivores (mostly insects). Post-harvest is mainly herbivores (insects and rodents).

Major pests are insects, nematodes (worms that eat the roots), bacterial and viral diseases (tobacco mosaic virus, dutch elm disease), weeds, rodents and birds.

Weeds

Weeds are the major problem in terms of crop loss They compete with crops for light, water, and nutrients. Ex. Soybean crop can be reduced 60% of there is cocklebur weed competing. Weed control accounts for 60% of all pesticide sold in US.

History of Pesticides

Early pesticides were **broad spectrum**, they killed lots of things, but this sometimes included some beneficial organisms, and the pesticides could also be harmful to humans. The ideal pesticide is a **magic bullet,** a **narrow spectrum** pesticide which kills a single species but harms nothing else.

DDT [Closer look 12.2 pg 228]

DDT is a chlorinated hydrocarbon. It appeared to have no effect on people and kill only insects. It was used during wartime to protect soldiers against malaria and yellow fever (and is still used this way). It did not dissolve in water, which made it seem like not an environmental problem (as you'll see this ends up being the key to the problem).

BUT.. (1) it has long term effects on non-insects, especially its effect on egg thinning in exposed birds and increased cancer in other organisms (2) it is stored in fats (because it is not water-soluble) and so it is passed up the food chain through **biomagnification.** The DDT found its way into water where it was absorbed by algae → plankton → little fish → big fish → birds (like brown pelican and golden eagle or bald eagle). As a result

DDT was banned in US in 1971, but US still produces it for oversees use (mostly for disease control).

Secondary pest outbreaks

Secondary pet outbreaks occur when a pest appears to have been beaten, but a pest population booms again. This occurs two ways: (1) a competing pest species gets a chance to thrive because its competition is gone; (2) natural selection has occurred and a resistant population has emerged.

Integrated Pest Management (IPM)

IPM is an ecosystem approach to pest management.

(1) use natural enemies like parasites, diseases and predators

(2) plant a greater diversity of crops

(3) no-till agriculture – enemies of nematodes build up in soil

(4) careful application of highly specific chemicals

Biological Control

Predator, parasites, parasites.

Ex. Ladybugs eat aphids on rose bushes

Ex. A bacteria, *Bacillus thuringiensis* kills larae of of many caterpillars, which love to eat leaves. Some wasps also lay eggs in caterpillars, killing them. These wasps are narrow spectrum

Ex. Sex pheremones, which confuse and trap pest species.

Generically Modified Crops

New Hybrids

This mimics a natural process of hybridization. The concern is the creation of "superhybrids" that are s productive they grow where not wanted and become pests.

The Terminator Gene

A gene that makes crops infertile – designed to prevent the spread of gmcs into natural populations. An economic concern is farmers in developing nations that would have to buy new seeds each year, rather than being able to grow seeds from their on crop.

Gene Transfer

Genes can be moved from one species to another – ex. A gene from a bacteria toxic to caterpillars move to potatoes and corn. Rice has been modified to improve nutritional value (bet carotene).

Grazing

Grazing is when livestock roam a piece of land eating the vegetation which grows there. **Overgrazing** reduces the diversity of plant species and can lead to an overabundance of the plants undesirable to the livestock. It can also increase erosion due to vegetation loss. Goats can be especially damaging.

In modern industrialized agriculture, cows are raised on range then transported to **feedlots**, where they are fed grain and live in high densities. The animal waste can be a pollution problem, especially after large rainfalls. This applies to cattle and pigs (swine).

Cattle, sheep, goats and horses have been exported to all over the world. One recent major impact of this has been the cutting of rainforest to create pasture for cattle in order to make money. The soil does not recover and the land becomes desertified quickly.

Game ranching is maintaining wild animals to be harvested for meat, leather, and other products. It is done with zebra and bison.

Desertification

The crucial factor in deserts is the amount of water available in the soil for plants to use. There are 5 natural desert regions on earth, but human activities (especially agriculture) are creating new deserts. About 33% of earth should be desert, but 43% of land is desert.

Desertification is caused when **marginal lands**, which have just enough rainfall to make the area more productive than a desert, are used for crop production and grazing. When the topsoil is ost to erosion, the land can no longer hold moisture and the land is desertified.

Causes of desertification:

bad farming practices
overgrazing
conversion of range to crop in marginal lands
poor forestry practices
poisoning of soils (by pesticides or industrial processes)
irrigation leading to high salt content in soils

Symptoms of desertification:

Lowering of water table
Increase salt content of soil
Reduced surface water
Increased soil erosion
Loss of native vegetation

Preventing Desertification

Monitor symptoms like aquifers and soils
Use proper methods of soil and forest management

Does Farming change the biosphere? (Global Effects of Agriculture)

Agriculture changes land cover which changes **albedo**, the reflection of light, evaporation of water roughness of surface and rate of chemical cycling.

Agriculture increases CO2 by: (1) using a lot of fossil fuels for machinery; (2) clearing land, which increases soil decomposition.

Agriculture can effect climate through fire, which is sometimes used to clear land. Fires release particulates.

Agriculture uses artificial fertilizers. Thgis may be leading to significant changes in the global nitrogen cycle. Excess runoff can create eutrophication.

Agriculture reduces diversity in competing ecosystems.

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