The Human Population, its Ecological Footprint, GHG Emission, Production and Distribution of Food

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Three models of population growth

- **J-curve**: Constant growth
- **S-curve**: Carrying capacity (K)
- **S-curve**: Generations
Real-life growth

- Population explosion
- Overgrazing and then dying off due to starvation
- Population held in balance by environmental resistance

Carrying capacity (K)
Biotic potential and environmental resistance

**Biotic Potential**
- Reproductive rate
- Ability to migrate (animals) or disperse (seeds)
- Ability to invade new habitats
- Defense mechanisms
- Ability to cope with adverse conditions

**Environmental Resistance**
- Lack of food or nutrients
- Lack of water
- Lack of suitable habitat
- Adverse weather conditions
- Predators
- Disease
- Parasites
- Competitors
Survivorship curves
World population over the centuries
Hunter-gatherer culture
Industrial revolution 17th & 18th centuries
The medical revolution

• Before the early 1800s, human populations grew slowly and fluctuated
  • Diseases (smallpox, diphtheria, measles, scarlet fever) hit infants and children hardest
  • Epidemics (e.g., the black plague) killed adults
• High reproductive rates were balanced with natural enemies (e.g., diseases), resulting in a low population growth rate
The green revolution

- Concerns over producing food for the larger population led to increased agricultural efficiency
  - Pesticides, irrigation, and fertilizer increased yields
  - Countries could feed their growing populations
- Industrialized agriculture came at significant costs
  - Erosion, soil and water pollution, loss of native plants
  - Resources (soil, water) were used faster than they were replaced
- **Resistance**: target organisms are no longer affected by pesticides
The newest revolution

• Technological breakthroughs
  • Have produced the Internet, computers, nanotechnology, robotics, and solar and other technologies

• Environmental revolution: will come from
  • Efficient technologies, urban and regional planning
  • Policy and industrial changes
  • Personal decisions

• Humans are part of the natural world although they can produce drastic changes
  • Natural laws still apply to people
Maximum sustainable yield

(a) Maximum rate of increase in population size

(b) Yield reduced by competition
Optimal population size for harvesting
Yield reduced by decreased population
Rate of recruitment to population

Relative population size
Time
Carrying capacity
High
Low
Do humans have a carrying capacity?

- It is hard to determine a carrying capacity for people
- Some people (e.g., economist Julian Simon) say that human ingenuity is the ultimate resource
  - There is no human carrying capacity
  - In the past, people have overcome carrying capacity
- Ecologists and demographers say humans are subject to limits and natural laws of population growth
- Humans have increased their carrying capacity
  - Technology, agriculture, trade, fossil fuels, and medicine
II. RICH, MIDDLE-INCOME, AND POOR NATIONS

- The World Bank puts countries into economic categories based on average per capita gross national income
- **High-income, highly developed, industrialized countries**
  - 1 billion: U.S., Canada, western Europe, Taiwan, Israel
- **Middle-income, moderately developed countries:**
  - $936-$11,455/yr
  - 4.3 billion: parts of Africa, China, some Arab states
- **Low-income, developing countries:** < $936/yr
  - 1.3 billion: parts of Africa, southern Asia, some former Soviet republics
Major economic divisions of the world
Developed and developing countries

- **Developed countries**: high-income nations
- **Developing countries**: middle and low-income nations

- Terms no longer used: more developed countries (MDCs), less developed countries (LDCs), third-world countries

- The UN Development Program (UNDP) uses the *Human Development Index* to measure general well-being
  - Based on life expectancy, education, per capita income

- *Human Poverty Index*: uses literacy and living standards
  - Directly measures poverty
Total fertility rates around the world

Total fertility rate around 2008
- Fewer than 1.5 births per woman
- 1.5 to 2.1 births per woman
- 2.2 to 2.9 births per woman
- 3.0 to 4.9 births per woman
- 5.0 or more births per woman

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The impact of wealth

• Wealth can help solve environmental problems
  • The rich can afford technologies to lower pollution, clean water, treat sewage, etc.
  • Environmental laws improve the environment
  • Technology helps people minimize degradation

• But the relationship between economic wealth and environmental health is not so clear-cut
  • Some issues (disease) may improve, but others (waste) increase
  • Environmental problems are pushed into other areas
The environmental footprint

- Arguments that overpopulation is not a problem fall flat
  - High-density places (e.g., Hong Kong) can be so crowded because they use resources from all over
- **Ecological (environmental) footprint**: estimate of the amount of land and ocean required to provide resources and absorb wastes
  - Pollution, climate change, toxic wastes, species loss, etc. result from high consumption associated with affluence
  - https://www.greencred.me
III. CONSEQUENCES OF POPULATION GROWTH AND AFFLUENCE

- Expanding populations and increasing affluence brings trouble for the environment
- Before the Industrial Revolution, small, isolated populations lived through subsistence agriculture
  - Medicine reduced death rates and populations grew
- 75% of the poor are engaged in small-scale agriculture
  - Farms become too small to support people
  - Few options are available: land reform, intensive cultivation, new land, illegal activities, emigration
Small-scale agriculture
Population profiles of the United States
Projecting future populations: a developed country

(a. 2005)

(b. 2025)
Projecting future populations: a developing country

![Population Pyramids for a Developing Country](image)

- **a. 2005**
- **b. 2025**

Population (in millions)
Growth impacts

• If a country with a high fertility rate wants to maintain its current standard of living, housing, facilities, food, jobs, etc. must be doubled in 25 years
  • Population growth can cancel out economic advances
• Little population growth will occur in developed countries
• Developing countries will have enormous growth, even with decreasing fertility rates
Comparing projected populations
Demographic transition in developed and developing countries
I. PATTERNS OF FOOD PRODUCTION

• 12,000 years ago the Neolithic Revolution introduced agriculture and animal husbandry
  • Fostered development of civilization
  • Major crops and animals were established in the first 1,000 years

• Food exchange and discovery (1450–1700)
  • From the New World: potatoes, maize, beans, squash, tomatoes, pineapples, cocoa
  • From the Orient: rice
  • From Europe: wheat, onions, sugarcane, animals
Traditional versus modern farming
Components of the agricultural revolution

- *Infrastructure*: transformed agriculture
- *Machinery*: handles every need for working soil
- *Land under cultivation*: since 1960, increased yields and surpluses reduced the need for land conversion. Globally, valuable and fragile forests and wetlands are converted to cropland
- *Fertilizers*: increase yields
- *Pesticides*: control insect and plant pests
- *Irrigation*: occurs on 18% of all cropland
- *High-yielding varieties of plants*: 
The Green Revolution

- **The Green Revolution**: technologies that resulted in remarkable increases in crop production
- In 1943, Norman Borlaug and others bred dwarf hybrid wheat with a large head and thick stalk
  - Mexico tripled wheat production
  - Borlaug was awarded the Nobel Peace Prize in 1970
- Many other countries increased crop yields
  - Grain production exceeded population growth
- The Green Revolution has done more than any other single achievement to prevent hunger and malnutrition
Traditional versus high-yielding wheat
Impacts of the Green Revolution

• Research now focuses on disease, pests, and climatic stresses
• The early revolution helped Asia and Latin America
  • Later years mainly helped Africa and the Middle East
• Without a Green Revolution, yields in developing nations would have been lower
  • Would have led to higher food prices, more cultivated land, increased hunger, and higher infant mortality
• Sub-Saharan Africa still lags behind in agriculture
  • Due to the dominance of subsistence agriculture
The yield gap for cereals

- Developed countries
- South Asia
- East Asia & Pacific
- Sub-Saharan Africa
- Latin America & Caribbean

Yield, tons per hectare

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Subsistence agriculture

- *Subsistence farming*: developing world farmers use labor-intensive traditional agricultural methods
  - Practiced on marginal land
  - Described as the “silent giant” that feeds most of the world’s poor
- **Subsistence farmers** live on small plots of land
  - They raise food for their household
  - They may sell a small cash crop
  - They do not consider themselves poor
- Subsistence farming is practiced in regions with rapid population growth
  - But is best suited for low population densities
Subsistence farming
Alliance for a Green Revolution

- Money from wealthy countries allows subsistence farmers to:
  - Improve irrigation, soil health, and markets
  - Grow enough food for their families
  - Produce enough to encourage economic development
- Subsistence agriculture works well in some areas
- Slash-and-burn agriculture: involves shifting cultivation within tropical forests
  - Cleared land supports a few years of crops
  - Gradually shifts into agroforestry (tree plantations with ground crops)
Animal farming and its consequences

• 25% of the world’s croplands feeds domestic animals
  • 70% of U.S. grain goes to animals
• The livestock economy: one of the most important activities
  • Four billion four-footed animals; 18 billion birds
  • People enjoy eating meat and dairy products
• In the developed world, animals are raised in confined animal feeding operations (CAFOs)
  • In the developing world, animals are raised on family farms or by subsistence farmers
Rain forest crunched

- 58 million acres (23 million hectares) of rain forests in Latin America have been converted to cattle pasture
- Most land is held by few ranchers with huge spreads
- Government policies encouraged colonization of land to produce meat for domestic use
- Cattle production in the Amazon basin has expanded
  - It is now export driven
  - Brazilian beef brings in $1.5 billion/year
Climate change

- Deforestation and other land use changes in the tropics release 1.6 billion tons/year of CO$_2$
- Livestock belching and flatulence release 100 million tons of methane/year
  - Methane is another greenhouse gas
- Anaerobic decomposition of manure releases 30 million tons of methane/year
- Methane released by livestock makes up 3% of all gases causing global warming
Biofuels and food production

- Burning fossil fuels causes climate change
  - Releases CO$_2$ (a greenhouse gas)
- **Biofuel**: a renewable fuel made from ethanol and oil derived from crops
  - Can mitigate climate change
  - No new CO$_2$ is released
  - With rising oil prices, biofuel prices are competitive
- Ethanol: made from corn (in the U.S.) and sugar (Brazil)
  - One-third of U.S. corn is devoted to ethanol production
  - Food prices have risen worldwide
Consequences

- Critics say ethanol diverts corn from food production
  - The U.S. produces 40% of the world’s corn and 55–60% of the corn on the market
  - Price increases take food away from children
- Does ethanol production decrease food?
  - Wheat, rice, and soy prices have risen more than corn
  - Land previously planted in soybeans is planted in corn
  - Field corn is used to produce ethanol
  - Only cornstarch is used for ethanol, leaving proteins, vitamins, and fiber to produce food
II. FROM GREEN REVOLUTION TO GENE REVOLUTION

• Genetic engineering incorporates desired traits into plants and animals
  • Producing transgenic (generically modified [GM]) organisms

• Genetic research of the Green Revolution used genes that already existed or mutated in a species

• Genes can now be exchanged among plants, animals, and bacteria

• This technology can help produce more food
  • But there are concerns about its development and use
The promise

- The earliest and most common genetically altered crops
  - Pest-resistant cotton
  - Herbicide-resistant corn and soybeans
- More recent crops include
  - Sorghum resistant to a parasitic plant (witchweed)
  - Insect-resistant corn, potatoes, cotton
  - Rapidly growing trees and salmon
- Farmers have grown transgenic corn, soybeans, and cotton
  - 282 million acres were planted with bioengineered crops in 2007
Objectives of agricultural biotechnology

• Stacked products: a crop containing two or more biotech genes
  • Traits directed toward different pests
  • For example, pest resistance plus herbicide tolerance

• Agricultural technology aims to:
  • Incorporate disease and pest resistance in tropical plants
  • Increase tolerance to drought, salt, etc.
  • Improve the nutritional quality of crops (e.g., golden rice)
  • Produce pharmaceutical products ("pharma crops")
Papaya plants in Hawaii
Environmental benefits of bioengineered crops

- Reduced pesticide use
  - Crops are already resistant to pests
- Less erosion
  - No-till cropping
  - Herbicide-resistant crops
- Less land brought into production
  - Existing agricultural land produces more food
Problems of genetic engineering: environmental concerns

- Pests may become resistant to the toxin in pest-resistant transgenic crops
  - The crop loses its advantage
  - Resistance has been found in weeds that infest fields
  - Resistant weeds can spread rapidly
- Pollen from transgenic crops can spread to natural areas
  - Kills beneficial insects
  - This occurred in monarch butterflies in the lab
- Genes can spread by pollen to ordinary plants
  - Create "super" weeds
Nilai Potensi Pemanasan Global dan Waktu Tinggal Gas Rumah Kaca dari Lahan Pertanian

<table>
<thead>
<tr>
<th>Gas</th>
<th>Waktu Tinggal di Atmosfer (tahun)</th>
<th>Potensi Pemanasan Global (CO$_2$-eq)</th>
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<tr>
<td>CO$_2$</td>
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<td>CH$_4$</td>
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<td>N$_2$O</td>
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Sumber: IPCC 3nd Assessment report, 2007
Perhitungan emisi gas rumah kaca

Perhitungan emisi gas rumah kaca dibagi menjadi empat perhitungan, yaitu:

1. Perhitungan tingkat emisi GRK kegiatan perdagangan dan penggunaan energy
2. Perhitungan tingkat emisi GRK kegiatan proses industry dan penggunaan produk
3. Perhitungan tingkat emisi GRK kegiatan pertanian, kehutanan, dan penggunaan lahan lainnya
4. Perhitungan tingkat emisi GRK kegiatan pengelolaan limbah.
Sumber Emisi Gas Rumah Kaca (sektor energi)

Berdasarkan IPCC Guideline 2006, sumber emisi GRK dari sektor energy diklasifikasikan ke dalam tiga kategori utama, yaitu:

• emisi hasil pembakaran bahan bakar,
  • Pembakaran bahan bakar adalah oksidasi bahan bakar secara sengaja dalam suatu alat dengan tujuan menyediakan panas atau kerja mekanik kepada suatu proses.

• emisi fugitive pada kegiatan produksi dan penyediaan bahan bakar, dan
  • Yang dimaksud emisi fugitive adalah emisi GRK yang secara tidak sengaja terlepas pada kegiatan produksi dan penyediaan energi, misalnya operasi flaring dan venting di lapangan migas, kebocoran-kebocoran gas yang terjadi pada sambungan-sambungan atau kerangan-kerangan (valves) pada pipa salur gas bumi dan gas CH₄ yang terlepas dari lapisan batubara pada kegiatan penambangan batubara

• emisi dari pengangkutan dan injeksi CO₂ pada kegiatan penyimpanan CO₂ di formasi geologi.
Start

Apakah ada pengukuran emisi?

Apakah semua sumber dalam kategori sumber diukur?

Apakah kontribusi bahan baku spesifik untuk kategori tersebut tersedia?

Apakah ada model estimasi yang detail?

Apakah ada FE country spesifik?

Apakah ini kategori kunci?

Gunakan pendekatan tier 3

Yes

Yes

Yes

Yes

Dapatkan data country spesifik

Gunakan pendekatan tier 3 digabung dengan tier 1

No

No

No

No

No

Yes

No

Yes

Yes

Dapatkan data country spesifik

Gunakan FE country spesifik

Sumber : IPCC 2006 Vol 2 Chapter 2
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<td>4 of 4 (CO₂, CH₄ and N₂O from fuel combustion by source categories – Tier 1)</td>
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<th>Energy consumption</th>
<th>CO₂ Emissions</th>
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<td>A (Consumption) (Ton)</td>
<td>B (Conversion Factor) (TJ/unit)</td>
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<td>C=A*B</td>
<td>E=C*D/10^6</td>
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### Biomass Information Items

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<th>Biomass</th>
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Grafik 4. 8 Emisi CO2eq Sektor Energi