Lecture 5: Basic Population Dynamics

CE 107: Introduction to Civil and Environmental Engineering
Population Density

Historical Population Density - 1994

Map showing population density across the world in 1994, with varying colors indicating different densities.
The Demographic Divide: Developed and Developing Nations

• A. Rich Nations

1. Decreased birth rates
2. Low to negative growth rates
3. Increased consumption rates per person
4. Negative environmental impact due not to numbers but affluence.
5. Consequences of affluence
   a. Greater contribution per person to global pollutants carbon dioxide, ozone depletion chemicals
   b. Food consumption high on biomass pyramid fewer people can be supported
   c. Waste production high fuel inefficient transportation, throwaway consumer goods.
Developed and Developing countries

• B. Poor Nations

1. Moderate birth rates (these rates have decreased in the last 20 years)
2. Moderate to high growth rates
3. Low consumption rates per person
4. Negative environmental impact due to numbers not affluence
5. Consequences of population size
   a. Subdividing farms and intensifying cultivation
   b. Opening up new lands for agriculture
   c. Migration to cities
   d. Illicit activities
   e. Emigration and immigration
   f. Impoverishment of women and children
Developed and Developing countries

Fig. Developing countries represent a larger and larger share of world population because of higher populations and higher birth rates.
Population Explosion

A. Current world population: 6 billion people (October 1999)

B. Putting the numbers in perspective:
   • Each time your heart beats, 3 more people are added to the world
   • Each time a person dies, 2.8 babies are born Every **day** a quarter of a million are added.
   • Every **year**, about 87 million people (about the population of Mexico, or 3x the population of California, or the combined populations of the Philippines and South Korea) are added to the world.
   • During the next **2.5 years**, the equivalent of the U.S. population will be added to the planet.
   • During the coming **decade** the increased population of one billion people is the equivalent of adding an extra China to the world's population

C. Causes of population growth:
   a. Better recruitment resulted from declining infant mortality rates
   b. Mortality rates decline:
      · Improvement in agriculture  increased production and better food distribution and storage
      · Public health measures  improved sanitation practices, clean drinking water, mass inoculations
For most of human history, population grew slowly, but in modern times it has suddenly "exploded. World population started a rapid growth phase in the early 1800s and has grown sixfold in the last 200 years. It continues to grow by nearly 88 million people per year."

World Population: The Reality and Projections

<table>
<thead>
<tr>
<th>#</th>
<th>Top ten most populous countries</th>
<th>1990</th>
<th>2008</th>
<th>2025*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>1,141</td>
<td>1,333</td>
<td>1,458</td>
</tr>
<tr>
<td>2</td>
<td>India</td>
<td>849</td>
<td>1,140</td>
<td>1,398</td>
</tr>
<tr>
<td>3</td>
<td>US</td>
<td>250</td>
<td>304</td>
<td>352</td>
</tr>
<tr>
<td>4</td>
<td>Indonesia</td>
<td>178</td>
<td>228</td>
<td>273</td>
</tr>
<tr>
<td>5</td>
<td>Brazil</td>
<td>150</td>
<td>192</td>
<td>223</td>
</tr>
<tr>
<td>6</td>
<td>Pakistan</td>
<td>108</td>
<td>166</td>
<td>226</td>
</tr>
<tr>
<td>7</td>
<td>Bangladesh</td>
<td>116</td>
<td>160</td>
<td>198</td>
</tr>
<tr>
<td>8</td>
<td>Nigeria</td>
<td>94</td>
<td>151</td>
<td>208</td>
</tr>
<tr>
<td>9</td>
<td>Russia</td>
<td>148</td>
<td>142</td>
<td>137</td>
</tr>
<tr>
<td>10</td>
<td>Japan</td>
<td>124</td>
<td>128</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>World total</td>
<td>5,265</td>
<td>6,688</td>
<td>8,004</td>
</tr>
</tbody>
</table>
### World Population growth

<table>
<thead>
<tr>
<th>Billions</th>
<th>Time to Reach Billion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Billion</strong></td>
<td>All of Human History (1800)</td>
</tr>
<tr>
<td><strong>2nd Billion</strong></td>
<td>123 Years</td>
</tr>
<tr>
<td><strong>3rd Billion</strong></td>
<td>33 Years (1960)</td>
</tr>
<tr>
<td><strong>4th Billion</strong></td>
<td>14 Years (1974)</td>
</tr>
<tr>
<td><strong>5th Billion</strong></td>
<td>13 Years (1987)</td>
</tr>
<tr>
<td><strong>6th Billion</strong></td>
<td>12 Years (1999)</td>
</tr>
<tr>
<td><strong>7th Billion</strong></td>
<td>14 Years (2013)</td>
</tr>
<tr>
<td><strong>8th Billion</strong></td>
<td>15 Years (2028)</td>
</tr>
<tr>
<td><strong>9th Billion</strong></td>
<td>26 Years (2054)</td>
</tr>
</tbody>
</table>
Carrying capacity of the Earth environment

• Definition: A concept related to sustainability which is usually defined as the maximum number of individuals of a species that can be sustained by an environment without decreasing the capacity of the environment to sustain that same amount in the future.

• What is the maximum number of people that Earth can sustain?
How many people can Earth Support?

May vary from 2.5 billion to 40 billion.
  2.5 bill: if everybody eat like Americans
  40 bill: if all flat lands are cultivated

Factors need to be considered

- **Food supply**
  - Support 6 billion if vegetarian. Agriculture production is not increasing much since 1984.

- **Land and Soil Resources**
  - Almost all usable land areas for agriculture used. 13% increase is possible, but extremely costly.

- **Water Resources**
  - Consumption ~ 1000 liters/day, rural ~ 5 liters/day. Only 1% freshwater is available for effective human use

- **Net primary productions**
  - Human uses 4% of land and 2% of oceans production. Since 1950, NPP of the planet decreased by around 13%.

- **Population density**
  - Bangladesh has 915 people /km²

- **Technology**
  - 1 American = 35 Indian = 140 Bangladeshi (??)
Population and Consumption

The “ecological footprint”
- The environmental impact of a person or population
  - Amount of biologically productive land + water
  - For resources and to dispose/recycle waste
- Overshoot: humans have surpassed the Earth’s capacity to support us

Ecological footprints are not all equal
- The ecological footprints of countries vary greatly.
  - The U.S. footprint is much greater than the world’s average.
  - Developing countries have much smaller footprints than developed countries.
Population and Consumption

The Ecological Footprint

Measures:
- how fast we consume resources and generate waste

Compared to:
- how fast nature can absorb our waste and generate new resources

- Energy
- Settlement
- Timber & paper
- Food & fibre
- Seafood

- Carbon Footprint
- Built-up land
- Forest
- Cropland & pasture
- Fisheries
Your Footprint : Example ..food

• Vegetarian: Food footprint 0.2 hectares
• Eat meat now and then: Food footprint 0.6 hectares
• Eat meat a few times a week: Food footprint 1.3 hectares
• Eat meat most days: Food footprint 2.1 hectares
• Eat meat once or twice a day: Food footprint 2.8 hectares
• Eat meat almost every meal: Food footprint 3.5 hectares
We are increasing the burden on our planet

• Human population growth amplifies all environmental problems
  - The growth rate has slowed, but we still add over 200,000 people to the planet each day.

• Our consumption of resources has risen even faster.
  - Life has become more pleasant for us so far.
  - However, rising consumption increases the demands we make on our environment.
  - The rise in affluence has not been equal. The gap between rich and poor has doubled in the past 40 years.
Consequences of a Population Explosion in Developing Countries

The diagram shows the numerous connections between unchecked population growth and social and environmental problems.
The Demographic Transition

1. Epidemiologic transition
   a. Pattern of change in mortality factors
   b. Decline in death rates

2. Fertility transition
   a. Pattern of change in crude birth rates
   b. Decline in birth rates worldwide

3. Phases of demographic transition
   a. The demographic transition is a description of the correlation observed in developed countries between economic development and decreased fertility rates. There may be other, equally effective means of reducing fertility rates.
The Demographic Transition
The Demographic Transition

Fig. 7.8 In developed countries, the decrease in birth rates proceeded soon after and along with the decrease in death rates, so very rapid population growth never occurred.
The Demographic Transition

Fig. 7.8b In developing countries, both birth and death rates remained high until the mid 1900s. Then a steep decline in death rates was caused by the rapid introduction of modern medicine, whereas birth rates remained high, causing very rapid population growth.
Age Structure

- The proportion of the population in each age class. Age structure provide insight into a population’s history.
- The age structure of a population affect current and future birth rates, death rates; and growth rates.
- Rapidly growing nation has shape like pyramids.
- In developing country 37% population are under 15.
- Slow growing nation has eye shape.
Age Structure

(a) Rapid growth
Nigeria

(b) Slow growth
United States

(c) Decline in growth
Germany

Raven/Berg, Environment, 3/e
Figure 8.14

Harcourt, Inc.
Age Structure

Population age profiles, 1985 and 2025

- Developing countries
- Age groups: 80-84, 75-79, 70-74, 65-69, 60-64, 55-59, 50-54, 45-49, 40-44, 35-39, 30-34, 25-29, 20-24, 15-19, 10-14, 5-9, 0-4

- Male
- Female

Millions

300
200
100
0
100
200
300
50
0
50
Projected Future Trends

This figure shows projected world population according to three different fertility scenarios. UN projections of the future world population, using different total fertility rates.
Reality of the problem

Fig. Poverty, environmental degradation, and high fertility rates become locked in a self-perpetuating vicious cycle.
Population Impact on the Environment

- Environmental Impact (EI)
  \[ EI = P \times A \times T \]

- Population (P)
- Affluence (A)
- Technology (T)

Number of people
Number of units of resources used per person
Environmental degradation and pollution per unit of resource used

Environmental Impact of Population