EARTH: THE APPLE OF OUR EYE

introduction

Only about 3 percent of the Earth’s surface is capable of growing food. Over the past century, farming technology has made it possible to produce more food from the world’s limited cropland in order to feed the growing world population. However, much of this **arable** (farmable) land has been taken out of production for urban/suburban development and livestock grazing, or has been mismanaged, leading to irreparable soil erosion. By 2050, food production must increase by 70 percent to feed the expected 9 billion people who will be sharing the planet.¹ Protecting our arable land resources is becoming more important than ever.

**Vocabulary:** arable, crop rotation, deforestation, erosion, fallow, hectare, over-farming, overgrazing, topsoil

materials

Part 1:
- Apple
- Knife

Part 2:
- None

Part 1: The Size of Arable Land

procedure

Slice the apple according to the instructions, narrating as you go.

concept

Farmland is an essentially nonrenewable resource that we depend upon for our food. As the population grows, food needs increase but farmland is often diminished.

objectives

Students will be able to:
- Identify what fraction of the Earth is made up of habitable/in hospitable land, developed land, and farmland.
- Discuss threats to farmland and ways it can be preserved.
- Interpret a graph of population and arable land over time and discuss the relationship.

subjects

Environmental Science (General and AP), AP Human Geography, Geography, World History, Algebra

skills

Observing, understanding cause and effect, interpreting bar and line graphs, identifying trends

method

A visual demonstration of the limited farmland available on Earth, followed by an analysis of arable land per capita over time.
<table>
<thead>
<tr>
<th>Apple</th>
<th>Earth</th>
<th>Narrative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Apple</td>
<td>Planet Earth</td>
<td>Hold the apple out so the class can see it.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“This apple represents our planet.”</td>
</tr>
<tr>
<td>3/4 Water</td>
<td></td>
<td>Cut the apple into quarters. Hold out 3/4 in one hand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ask the class, “What do these 3/4 represent?” (Water.)</td>
</tr>
<tr>
<td>1/4 Land</td>
<td></td>
<td>Set the three “water” sections aside and hold out the remaining quarter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ask the class, “What fraction of the apple remains?” (1/4) “So, this 1/4 represents the total land surface.”</td>
</tr>
<tr>
<td>1/8 Inhospitable &amp; non-arable land</td>
<td>Slice the land (the remaining 1/4) in half, lengthwise.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hold out one of the pieces and ask the class, “What fraction of the apple is this?” (1/8) “This 1/8 represents the Earth’s land that is inhospitable to people and to crops: the polar regions, deserts, swamps, and high or rocky mountains.”</td>
</tr>
<tr>
<td>1/8 Habitable land</td>
<td>Set that 1/8 aside and hold out the other.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>“This 1/8 represents the other half of the Earth’s land. These are the areas where people can live but can’t, or don’t, necessarily grow food.”</td>
</tr>
<tr>
<td>3/32 Habitable, but not used for farming</td>
<td>Slice this 1/8 crosswise into four equal pieces.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hold out three of the pieces and say, “These 3/32 represent land on which people can live but cannot grow food. Some of it was never arable because it’s too rocky, wet, cold, steep or has soil too poor to produce food. Some of it used to grow crops but has since been developed – turned into cities, suburbs, highways, etc. Governments have earmarked other areas, such as parks, nature preserves, and other public lands to remain undeveloped forever.”</td>
</tr>
<tr>
<td>1/32 Arable land</td>
<td>Set the 3/32 aside and hold out the 1/32.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>“Only 1/32 of the Earth’s surface has the potential to grow the food needed to feed all of the people on Earth.”</td>
</tr>
<tr>
<td>1/32 Top soil</td>
<td>Carefully peel the 1/32 slice of Earth.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hold up the peel and say, “This tiny bit of peel represents the topsoil, the dark, nutrient-rich soil that holds moisture and feeds us by feeding our crops.”</td>
</tr>
</tbody>
</table>
Some Facts About Farmland

**Erosion** by wind and water is the most serious cause of soil loss and degradation. Although it is a natural process, erosion is accelerated greatly by things like construction, deforestation, unsustainable farming practices, and animal grazing.

- Around the world, soil is being swept away 10–40 times faster than it is being replenished, destroying roughly 23 million acres of cropland every year. As a result of soil erosion over the past 40 years, 30 percent of the world’s arable land has become unproductive.²
- In order to feed the 9 billion people expected in 2050, food production must increase by 70 percent.³
- Land degradation is intensifying in many parts of the world, with more than 24 percent of cultivated areas undergoing degradation, affecting one-fourth of the world’s population.⁴

**discussion questions**

1. What are things humans do to arable land that make it more vulnerable to erosion?

*Answers may include:*

- **Deforestation** – When trees are cut down, the soil loses the shelter of branches and leaves that protect it from the force of rain and wind that otherwise blow and wash it away. The root systems that hold the soil in place from underneath are also destroyed.
- **Over-farming** – Each kind of crop takes certain elements from the soil. Over-farming occurs when the same crop is grown in the same place for too many years in a row, and the soil can’t renew itself. Eventually, all of that particular element is gone, and that soil is unable to grow anything. One way to avoid this is **crop rotation**. Farmers divide their land into sections, and every year, they change the kind of crop grown in each section. One section might be left unplanted, or **fallow**, for a growing season, giving the soil microbes time to break down dead plant matter and/or animal matter into soil nutrients.
- **Overgrazing** – When cattle eat grass, they pull it out of the ground by the roots, taking some soil with it. Each bite leaves a patch of ground uncovered, exposed to the wind and the rain. These animals’ sharp hooves also tear up the surface a little with each step.

2. How do you think population growth contributes to the loss of arable land?

*Answers will vary. When population grows, more people need places to live and work so land is often developed. As more people become affluent and start to consume more animal-based diets, more land is required to meet this demand. Also, a growing population can mean more potential for pollution.*


Tell students that the graphic represents world population in 2017 and that each dot represents 1 million people. Why are some parts of the Earth not populated by dots? Do all countries or regions have an equal amount of arable land?

*Answers will vary depending on students’ geo-literacy and you may need to prompt them by asking about the climate/geography of these regions. The areas without dots are known for their harsh climates (e.g. tundra, desert, mountain, dense jungle/forest). Areas with harsh inhabitable climates have a smaller share of arable land. In other words, arable land is not distributed equitably around the world.*
4. How many people do you think the Earth can feed with its existing croplands?

Answers will vary. Although much of the hunger problem stems from uneven food distribution, rising affluence also plays a role in the number of humans that the world’s food supply can sustain. Per capita consumption of grain in a low-income nation such as India, whose people’s diets consist of primarily a single starchy staple like rice, is 200 kg/year. However, per capita consumption in a more developed nation like the U.S. or Canada is 800 kg of grains each year. Most of this grain is indirectly consumed from eating animal products such as beef, pork, poultry, eggs, milk, and other dairy products. In other words, the grain is used for animal feed instead of being directly consumed by people.

5. The current world grain harvest is 2 billion tons. How many people could we support if everyone consumed at:

a. the U.S. level of consumption (800 kg of grain per person for food and animal feed)?

b. the Italian level of consumption (400 kg of grain per person for food and animal feed)?

c. the Indian level of consumption (200 kg of grain per person for food and animal feed)?

Note: 1 ton = 907 kg

The world’s grain harvest could support about 2 billion Americans, 5 billion Italians or 9 billion Indians.

U.S.: 800 kg/907 kg = 0.88 tons/person; 2 billion tons/0.88 tons = 2.3 billion people
Italian: 400 kg/907 kg = 0.44 tons/person; 2 billion tons/0.44 tons = 4.5 billion people
Indian: 200 kg/907 kg = 0.22 tons/person; 2 billion tons/0.22 tons = 9.1 billion people
**Part 2: Our Arable History**

**procedure**

1. Display the Population vs. Arable Land/Person graph. Point out the two different variables, population (orange line) and arable hectares per person (blue bars) and the two different y-axis scales. Explain that this type of graph is often used to illustrate a relationship between two variables. The x-axis shows years.

2. Have students look at the title and define hectares/person: A hectare is 2.47 acres, or 10,000 square meters. To help students visualize this, tell them a baseball field from home plate to the start of the outfield is roughly a hectare.

![Population vs. Arable Land/Person graph, 1965-2010](image)

*Sources: The World Bank, Open Data; United State Census Bureau, International Data Base*

**discussion questions**

1. What is the overall trend of human population from 1965 to 2010?

   *Human population increased between 1965 and 2010. It grew from just over 3 billion to close to 7 billion.*

2. What is the overall trend of arable hectares per person during the same time period?

   *The amount of hectares per person decreased over time. In 1965, there were 0.35 hectares per person, and in 2010 there are just over 0.2 hectares per person. Converted to acres, that’s 0.86 acres/person in 1965 and 0.49 acres/person in 2010 (about half the size of a football field).*

3. What is the relationship between the amount of arable land per person and population size? Why do you think this is true?

   *Arable land isn’t increasing, as it is a finite resource. However, human population is growing steadily. As human*
population increases, the amount of arable hectares available per person decreases; each person’s “share” gets smaller and smaller. This is an inverse or indirect relationship – as one variable increases (population), the other decreases (arable land per person). Also, to support the demands of more people, arable land often gets used for other purposes like housing, roads, industrial purposes and so on, decreasing the total amount over time.

4. Do you think this relationship holds true if we look at the population and arable land of a country rather than the entire world? If yes, does that mean each country is impacted by an increasing population in the same way?

Yes, the relationship holds true and remains indirect. However, each country is not impacted by a growing population in the same way. A country with a small amount of arable land and a large population would have the fewest arable acres per person, and a country with a small population and a lot of arable land would have the most arable land per person.

5. How might a country that can’t support its population on its available arable land support its people?

They could import food or receive aid from other countries.

6. Human population is expected to increase to over 9 billion by 2050. How can we preserve farmland in order to feed everyone?

Answers may include:

- By not building on arable land – Land covered up by building, highways, and other forms of development can’t be used for growing crops.
- By eating lower on the food chain – While over a billion people suffer from malnutrition or starvation, meat production requires a disproportionate amount of grain input. Producing a pound of beef in a feedlot requires seven pounds of grain, a pound of pork requires four, and a pound of poultry requires two pounds of grain. The land that is used to produce grain for consumption by animals is inaccessible for growing grain for human consumption.
- By reducing pollution – Pollution impedes the ability of the land and the seas to provide food that’s both sufficient in quality and free of contaminants.
- By stabilizing human population growth – Food supply is an excellent example of the relationship between any resource and the size and consumption patterns of the population that depends on it. Simply put, the more people there are to feed, the less food there is to go around.

assessment

Students draw a diagram(s) or infographic that pictorially represents: the amount of arable land on the planet, the relationship between arable land and population size, and one way to preserve farmland.

follow-up activity
Have students imagine that they are citizens of a town that is rapidly growing, and the city council is considering expanding the urban area onto some nearby farmland. Have each student write an op-ed for a fictitious newspaper in this town explaining the consequences of doing so.

Part 1 adapted from an activity that first appeared in KUITATK, a Native American Science Education Association Issue Publication.


