Feeding the World - Human Populations

Science & Engineering Practices	Disciplinary Core Ideas	Cross Cutting Concepts
Analyzing and Interpreting Data	LS2.A: Interdependent Relationships in Ecosystems	Cause and Effect
Engaging in Argument from Evidence	MS-ESS3.C: Human Impacts on Earth's Systems	Influence of Science, Engineering, and Technology on Society and the Natural World

DRAFT

Feeding the World Human Populations - Storyline

Lesson/Routine	Questions	Phenomena/Problems	What We Figured Out
Anchoring Phenomena		World Population Clock https://worldpopulationhistory.org/map/2050/mercator/1/0/25/	• This clock tracks births on earth. • This counter increases by about 200,000 every day.
Lesson 1 Population Growth	• How many people are added in a minute? • How many people are added in our state? • How many people are added in the United States? • Where are people added in the world?	Students Analyze and Interpret Data to see how fast population increases. Resource availability does not seem to limit the growth of human populations in the same way as other organisms. Why is that?	Human population grew slowly up until 1960, then has increased rapidly since then, adding a billion every 12-14 years.
Lesson 2 Population Age Structures	• Where are all the people? • Why do populations grow so fast? • How can we predict population growth?	Population grows fastest in areas of the world that have the fewest resources or infrastructure.	Students use graphical representations in order to Analyze and Interpret Data to determine where the growth of populations is located in the world.
Lesson 3 Demographic Transition	• How do countries develop and change? • What effect do those developments and changes have on populations? • How do these changes affect the eating habits	Countries have changed over time through economic development. Those changes have an effect on how people work, live and eat.	As countries develop economically, their death rates decline, then their birth rates, then their food consumption patterns - turning more to higher protein foods.

Content designed by EducationProjects.org on behalf of the farmer boards at Ohio Corn & Wheat and the Nebraska Corn Board.

	of those populations?		
Lesson 4 Farming for the Future	• What percent of the world population is engaged in agriculture? • What type of agriculture is most frequently used? • How might farming change to help feed the world? • Will feeding the world lead to more population growth?	People who rely on subsistence farming are taking chances on weather, the types of crops to plant and the limits of yield. Education, infrastructure and health care is lacking in many of these countries.	While more than 2/3 of the population in poor countries work in agriculture, less than 5% of the population does in rich countries. The increase in productivity allows for fewer people to be involved in working on farms and makes it possible to reduce the agricultural land needed to feed a given number of people.

Pre-/Post Assessment

Feeding the World and Human Population Growth

1. The human population is:
   A. Growing
   B. Declining
   C. Stable

2. Which of the following statements is true?
   A. The countries with the largest populations grow the fastest.
   B. The countries with the largest populations over 45 grow the fastest
   C. The countries with the largest populations under 15 grow the fastest.
   D. The countries with the largest populations between 15 and 45 grow the fastest.

3. If we feed all the people in the world, what will happen to the rate of growth of the world population?
   A. It will grow right away.
   B. It will decline right away.
   C. There will be no change in the current rate of growth.
   D. It will decline over time.

4. Subsistence farming methods create: (circle all that apply)
   A. Problems for the local ecosystem
   B. Enough food for local populations
   C. Enough food for regional and national populations
   D. Less than enough calories to feed all who depend on these methods

5. The total human population increases each day by:
   A. About 100,000 people
   B. About 200,000 people
   C. About 500,000 people
   D. About 1 million people

6. Which of the following factors impact human population growth?
   A. Birth rate
   B. Death rate
   C. Economic development
   D. Education level
   E. All of these
   F. None of these

Lesson 1: Population Growth - Teacher

Essential Questions: *How fast has population increased over human history? What might help slow the rate of increase?*

<table>
<tr><td colspan="2">DCI (Standard)</td></tr>
<tr><td colspan="2">MS-LS2.A: Interdependent Relationships in Ecosystems</td></tr>
<tr><td colspan="2">Performance Expectations</td></tr>
<tr><td colspan="2">MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
● [Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]</td></tr>
<tr><td>3 Dimensions</td><td>Classroom Connections</td></tr>
<tr><td>Science & Engineering Practices

Analyzing and Interpreting Data
● Analyze and interpret data to provide evidence for phenomena.</td><td>Students analyze and interpret data by organizing population data (e.g., using tables, graphs, and charts) to allow for analysis and interpretation.</td></tr>
<tr><td>Disciplinary Core Idea

LS2.A: Interdependent Relationships in Ecosystems
● Growth of organisms and population increases are limited by access to resources.</td><td>a) Students analyze the organized data to determine the relationships between the size of a population, the growth and survival of individual organisms, and resource availability.
b) Students determine whether the relationships provide evidence of a causal link between these factors.</td></tr>
<tr><td>Crosscutting Concept

Cause and Effect
● Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td><td>Students analyze and interpret the organized data to make predictions based on evidence of causal relationships between resource availability, organisms,</td></tr>
</table>

	and organism populations. Students make relevant predictions, including: ● Resource availability may have effects on a population's rate of reproduction.

Background

According to most estimates, there will be 9.5 billion people on the planet in 2050. Many experts suggest that growers will have to produce more food in the next 50 years than has been grown in the past 10,000, which is doubling current production on the same amount of land. Yield increases have begun to slow (see USDA graph). Therefore, this demand will require new technologies, new techniques and new environmental practices be developed.

What are the limits to the food production possibilities? The amount of arable land may decrease if climates continue to change. Water is limited around the world and the places that are most productive are not necessarily in the areas where food is most needed. Fossil fuels, even with the addition of ethanol, run tractors while fertilizers and pesticides are also energy intensive to create. Therefore, food production is closely tied to fuel costs and availability.

Another concern is the infrastructure that is necessary to get food to markets before it spoils. In many less economically developed countries, there is no system to get the food to market and storing it is not a viable option due to fungus and pests destroying it. Soil is also vulnerable to erosion, desertification (once fertile land becomes arid), salinization (build-up of salts in the soil from over-irrigation) and water-logging (saturation of soil by groundwater).

One of the largest problems in the developed world is food waste. Some of the crop is lost in the field to pests (about 30%), some is left during the harvest (10–20%), and in the U.S., it is estimated that consumers throw away as much of 50% of their food. Population pressures are driving today's food production demand. While the need to feed a growing population will continue, factors such as decreasing infant mortality rates, reducing the need for children to work, providing women with educational opportunities and access to family planning will improve the standard of living in countries worldwide and increase the demand for food. With 9

billion eaters, the agriculture industry, made up of large-scale farmers, local food producers, entrepreneurs, agriculture scientists and engineers will all become allies in meeting future food demands.
https://www.nass.usda.gov/Charts_and_Maps/graphics/cornyld.pdf
https://www.nass.usda.gov/Charts_and_Maps/graphics/soyyld.pdf

Phenomena
Begin this lesson with a one minute look at the World Population Clock. http://www.theworldcounts.com/counters/shocking_environmental_facts_and_statistics/world_population_clock_live This clock shows the number of people being added to the Earth's human population in real time.

After showing the clock for one minute, ask students to brainstorm questions individually for 30 seconds to one minute, then share their questions within small groups (3-4 students) for two-three minutes. Have groups share their questions one-by-one to the large group until all questions are shared. Keep note of the questions, as they will guide the rest of this unit.

Possible questions:

- How many people are added in a minute?
- How many people are added in our state?
- How many people are added in the United States?
- Where are all of these people?
- What is the rank of countries by population?
- Why are some countries growing faster than others?
- What are the effects of this growth?
- What effects do the growth of human populations have on ecosystems?
- Do we have enough food?
- Can we grow enough food?
- When did we grow so large as a human population?

If no one brings up food or food production, add your own questions: Do we have enough food to feed everyone? Where are the people and where is the food? How can we feed 9.8 billion people in 2050, and what happens along the way?

To begin investigating these questions, organize the ones that relate to the sheer number of people and the rate at which the population has grown.

See these resources for additional information:
https://ourworldindata.org/world-population-growth
https://worldpopulationhistory.org/map/2050/mercator/1/0/25/
http://www.theworldcounts.com/counters/shocking_environmental_facts_and_statistics/world_population_clock_live

Use Lesson 1: **Population Growth** to address some of those questions.

Materials
Students will need an electronic device to access the internet.
Students will work individually to complete the following steps.

1. Have students research the information by visiting
https://worldpopulationhistory.org/map/2050/mercator/1/0/25/

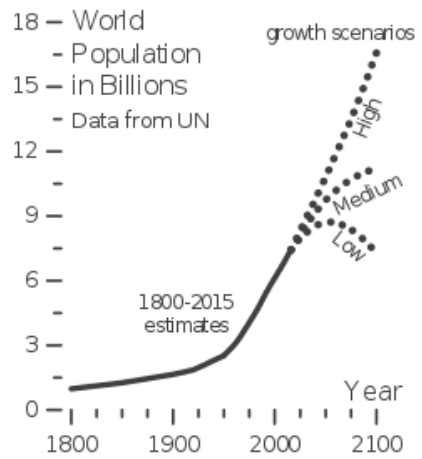
Ask:

- How many years has it taken for the world population to double?
- How many years has it taken for the world population to increase by 1 billion?

2. Students create their own table or use the example one to collect data on the years it has taken to reach each billion and to double.

Year	Population in billions	Number of years between	Years to double
1804	*1 billion*	*many*	
1928	*2 billion*	*124*	*124*
1960	*3 billion*	*32*	
1974	*4 billion*	*14*	*56*
1987	*5 billion*	*13*	
1999	*6 billion*	*12*	
2011	*7 billion*	*12*	
Estimated 2023	*8 billion*	*Estimated 12*	*Estimated 49*

3. *Possible Graph*



https://commons.wikimedia.org/wiki/File:World_population_v3.svg

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the population changes in their town, city, state or home country (https://census.gov/ to access local data)

ii. **Students with special needs (language/reading/auditory/visual)**: Teacher may supply a graph for students to interpret or only require the mathematical calculation without the graph.

iii. **Extra support**: students may model exponential growth by using objects (seeds, blocks, etc) to show rapid increase as numbers increase, or complete pedigrees of their own families from grandparents to their own generations. (ties to local community also)

iv. **Extensions**: Students can compare birth rates from previous decades to see the change over time, and how the growth rate has slowed, but the numbers are still adding up exponentially.

Reflection

1. What might account for the decreasing time between billions?

Possible answers: There are currently more people to have children than before; People have a higher life expectancy and lower infant mortality

2. How have humans utilized land resources to increase food production to allow for these increases?

Possible answers: Humans have improved farming methods, discovered and implemented the use of technology, cleared more land from forests.

3. What are the effects of technology when used in food production?

Possible answers: Technology can lead to increased yield, more efficiency by reducing time (using tractors and harvesters), less labor needed.

4. What factors must be considered to project future growth?

Possible answers: Demographers must consider cultural factors, limits imposed by governments, number of women of childbearing age, age at marriage, education of women, child mortality rates (the higher the mortality rate, the higher the rate of population increase), women in the workforce...

5. How do you explain that resource availability does not seem to limit human population growth?

Possible answers: We are at 7.6+ billion and still growing exponentially; we have enough food to feed people; we have enough land for people to live on; people are not dying in large numbers from starvation…

Assessment

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Rubric for Assessment

Skill	Beginning	Satisfactory	Exemplar
Student used graphical displays (graphs, and/or tables) of human population data sets to identify relationships over time or space.	Student recorded data but not in a table, chart or graph.	Student created a data table that organizes the data.	Student created a graph from organized data to show relationships.

Rubric for student self-assessment

Skill	Yes	No
I created a table to organize data.		
I created a graph to show relationships between data.		

Lesson 1: Population growth

Essential Questions: *How fast has population increased over human history? What might help slow the rate of increase?*

Materials
Electronic device with internet access

Procedure
1. Go to https://worldpopulationhistory.org/map/2050/mercator/1/0/25/

2. Create a table to record the year in which population increased by 1 billion. Add a third column to record the number of years it took to increase by 1 billion. Using the interactive map, determine the year the population increased by 1 billion. Calculate the number of years it took to increase by 1 billion or to double (where appropriate).

3. Graph these results on an app or by hand on graph paper.

Reflection
1. What might account for the decreasing time between billions?

2. How have humans utilized land resources to increase food production to allow for these increases?

3. What are the effects of technology when used in food production?

4. What factors must be considered to project future growth?

5. How do you explain that resource availability does not seem to limit human population growth?

Resources
https://ourworldindata.org/world-population-growth
https://worldpopulationhistory.org/map/2050/mercator/1/0/25/
http://www.theworldcounts.com/counters/shocking_environmental_facts_and_statistics/world_population_clock_live

Assessment

Analyze and interpret data to provide evidence for the increase in number of the human population.

Rubric for Assessment

Skill	Beginning	Satisfactory	Exemplar
Student used graphical displays (graphs, and/or tables) of human population data sets to identify relationships over time or space.	Student recorded data but not in a table, chart or graph.	Student created a data table that organizes the data.	Student created a graph from organized data to show relationships.

Rubric for student self-assessment

Skill	Yes	No
I created a table to organize data		
I created a graph to show relationships between data		

Lesson 2: Population age structures - Teacher

Essential Questions: *What is an age structure diagram? How does age structure affect population growth? Why is this important in food production?*

DCI

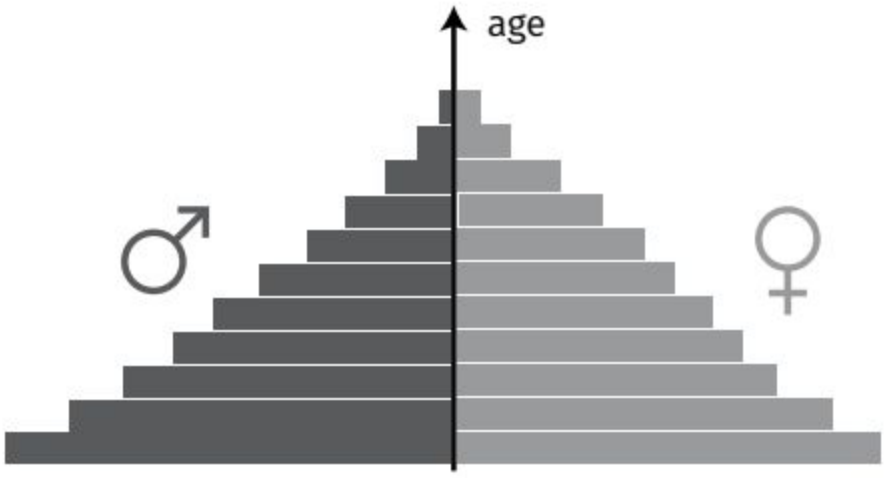
MS-LS2.A: Interdependent Relationships in Ecosystems

Performance Expectation	**Connections to Activity**
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.	Students analyze and interpret population age structures for evidence of whether resource availability affects human population growth.
Science & Engineering Practice	
Analyzing and Interpreting Data ● Analyze and interpret data to provide evidence for phenomena.	Human population is growing. Students analyze and interpret age structure diagrams to determine which countries have the largest potential for growth
Disciplinary Core Idea	
LS2.A: Interdependent Relationships in Ecosystems ● Growth of organisms and population increases are limited by access to resources.	Students analyze and interpret age structure diagrams to determine if access to resources is available in the countries that have the largest potential for growth.
Cross Cutting Concept	
Cause and Effect	Students determine which factors contribute to higher birth rates.

Students should work individually to complete this activity. If students are struggling, they can be paired to help each other to determine the predictive nature of the age structure diagram, but

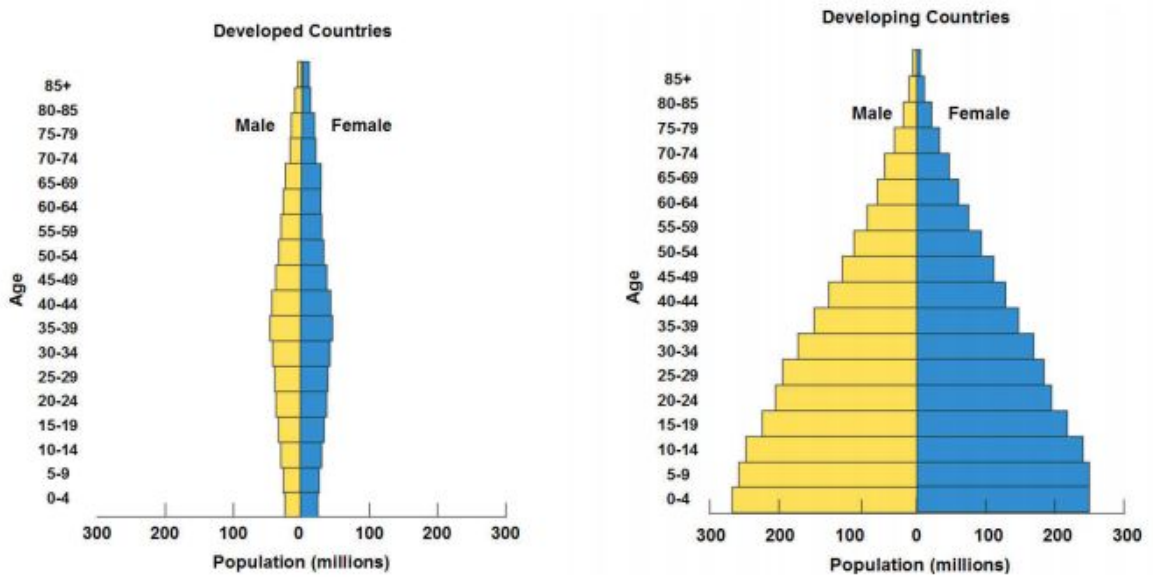
it is to be encouraged for all students to predict growth (low, medium, high or negative) from at least one age structure.

A population age structure diagram is the proportion of the population (and of each gender) at each age level. (Each level in the above graphic represents an age group in increasing order, youngest at the bottom and oldest at the top.)



1. Draw two lines on the pyramid above.
a. The first line should be drawn above the third level of the pyramid which encompasses the pre-reproductive age group, 0–14.
b. The second line includes the next six levels, so draw above the ninth level of the pyramid and is the reproductive age group (15–44).
c. Above the line drawn in b is the post-reproductive age group (44–85+).

These diagrams help to determine how a country's population will grow. Take a look at the two structures below:



2. Which of the structures above show imminent population growth?

Answer: The one on the right

The percentage (or the actual number) of the population that is of reproductive age is the percentage that will be responsible for increasing population, in addition to the percentage that will be reaching reproductive age in the following years. In the diagram to the left, the reproductive population is much smaller and there are fewer children in the age categories below the reproductive age groups. The populations of less developed countries are increasing at a greater rate than those of developed countries. In addition, a larger number of malnourished people also live in those developing countries. Almost all the hungry people, 780 million, live in developing countries, representing 12.9 percent, or one in eight, of the population of developing countries. There are 11 million people undernourished in developed countries (http://www.fao.org/state-of-food-security-nutrition/en/).

3. What are the implications of rapidly growing populations and more malnourished people in developing countries? What might a country do to decrease population growth? What has been done (i.e. China, Thailand, India policies)?

Possible answers: more people in less developed countries lead to more food insecurity, worsening health problems, more children struggling in school where education is accessible…

Countries have taken various approaches to slowing population growth - China required one child for many years (1979-2015); people were penalized if they had more than one child (https://www.thoughtco.com/chinas-one-child-policy-1435466). Thailand offered birth control to their population from 1971-1992 and lowered their population growth rate from 3.2%-1.6%. (https://www.context.org/iclib/ic31/frazer/) India tried forced

sterilizations in the 1970's (and still conducts sterilizations - 4 million in 2013-2014) that result in many people suffering from complications related to the surgeries. (https://www.bbc.com/news/world-asia-india-30040790)

In 1798, Thomas Robert Malthus predicted that short-term gains in living standards would be undermined as human population growth outstripped food production, and create a population crash. However, we have not seen this to be the case. Over the last half-century, world population doubled while food supply tripled, even as land under cultivation grew by only 12% (FAO, 2012). It is by raising productivity, or getting more output from existing resources, that has been driving growth in global agriculture, and has proven Malthus wrong. In fact, at the global level, the long-run trend since at least 1900 has been one of increasing food abundance—in inflation-adjusted dollars, food prices fell by an average of 1% per year over the course of the 20th Century - See more at: http:// http://www.choicesmagazine.org/UserFiles/file/article_90.pdf

Read the three statements below:

a. Agriculture employs over 1.3 billion people throughout the world, or close to 33 percent of the global workforce. http://www.fao.org/docrep/015/i2490e/i2490e01b.pdf
b. In about 50 countries, agriculture employs half of the population, and even 75 percent in the poorer nations.
c. Agriculture is the world's largest provider of jobs.

4. In light of the predictions of Malthus, the realities of food production since 1900, including the Green Revolution and new technologies which include genetic modification of various types, and precision agriculture techniques, what is your prediction about food production in the next 30 years? What strategies can we continue to use, or develop, to meet the needs of growing populations and changing demographics?

Possible Answers: food production will get more efficient; there is a movement in developed countries to go back to smaller scale farming and locally sourcing food; economies of scale may be applied to developing countries as they are in developed countries; Infrastructure needs to be improved; Distribution networks need to be developed; vertical gardens could be employed where feasible...

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the population age structures in their town, city, state or home country (U.S.- https://census.gov/ Access Local Data)
ii. **Students with special needs (language/reading)**: Structures may be increased in size for easier determination of numbers in each age group.
iii. Extra support: Video: https://www.youtube.com/watch?v=RLmKfXwWQtE *Population pyramids: Powerful predictors of the future - Kim Preshoff* This video helps to combine this lesson and the following one on Demographic Transition. There is also a lesson plan here:

https://ed.ted.com/lessons/population-pyramids-powerful-predictors-of-the-future-kim-preshoff

iv. Extensions: Students can research previous events that have affected the population changes (i.e. World War II, changing cultural norms in a country, etc.)

Reflection

1. Looking at the countries that have the largest potential for population growth, what are the causes of their large population growth?
   Possible Answers: There are more people in the reproductive age groups, lack of education of women, infant and child mortality, lack of access to contraception...
2. Are these causes related to resource availability?
   Possible Answers: Yes, resources including health care, education, technology, etc.

3. What are the ecosystem limits?
   Possible Answers: We may not know until it is too late (*Collapse* by Jared Diamond: "Twilight at Easter"); it is difficult to predict because we have not exceeded the limits but we can see the signs of overgrazing, soil salinization, desertification…

4. What can humans do to address those limitations?
   Possible Answers: technology that allows for growing food in non-native environments; genetic modification; precision farming methods that help to lessen the impact on ecosystems while still growing food

Assessment

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. Determine whether the age structure pyramid predicts population growth and if human populations are limited by resource availability based on the economic status of the country.

Rubric for assessment

Skill	Beginning	Satisfactory	Exemplar
Analyze and interpret data to provide evidence of whether resource availability affects human population growth.	Analysis includes some data that provides evidence that resource availability either does or does not affect human population growth.	Analysis includes specific age structure data that provides evidence that resource availability either does or does not affect human population growth.	Analysis includes data comparison across two or more different countries and includes interpretation of the predictive ability of the age structure diagram and that provides evidence

			that resource availability either does or does not affect human population growth.

Rubric for student self-assessment

Skill	Yes	No
I analyzed data from age structure pyramids to predict human population growth.		
I interpreted data from age structure pyramids to provide evidence that resource availability either does or does not affect human population growth.		

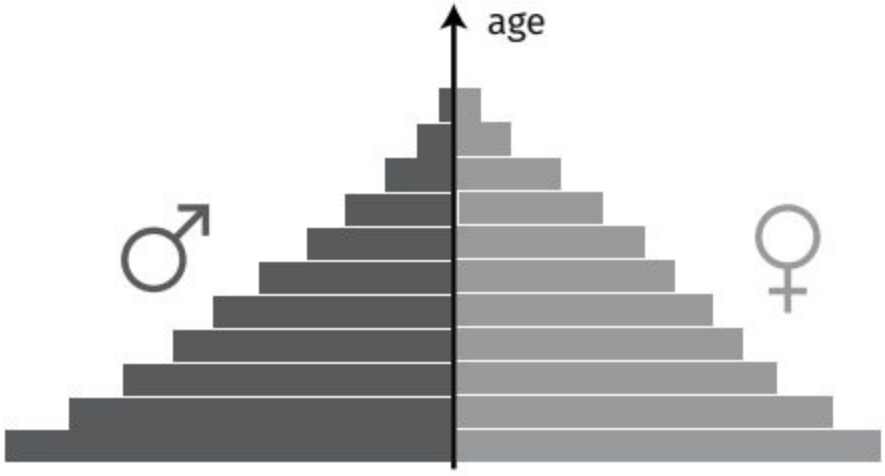
Additional resources

Hans Rosling - Religion and babies
https://www.ted.com/talks/hans_rosling_religions_and_babies
Hans Rosling - Global Population Growth
https://www.ted.com/talks/hans_rosling_on_global_population_growth

Lesson 2: Population age structures

What is an age structure diagram? How does age structure affect population growth? Why is this important in food production?

A population age structure diagram is the proportion of the population (and of each gender) at each age level. (Each level in the above graphic represents an age group in increasing order, youngest at the bottom and oldest at the top.)



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a. The first line should be drawn above the third level of the pyramid which encompasses the pre-reproductive age group, 0–14.
b. The second line includes the next six levels, so draw above the ninth level of the pyramid and is the reproductive age group (15–44).
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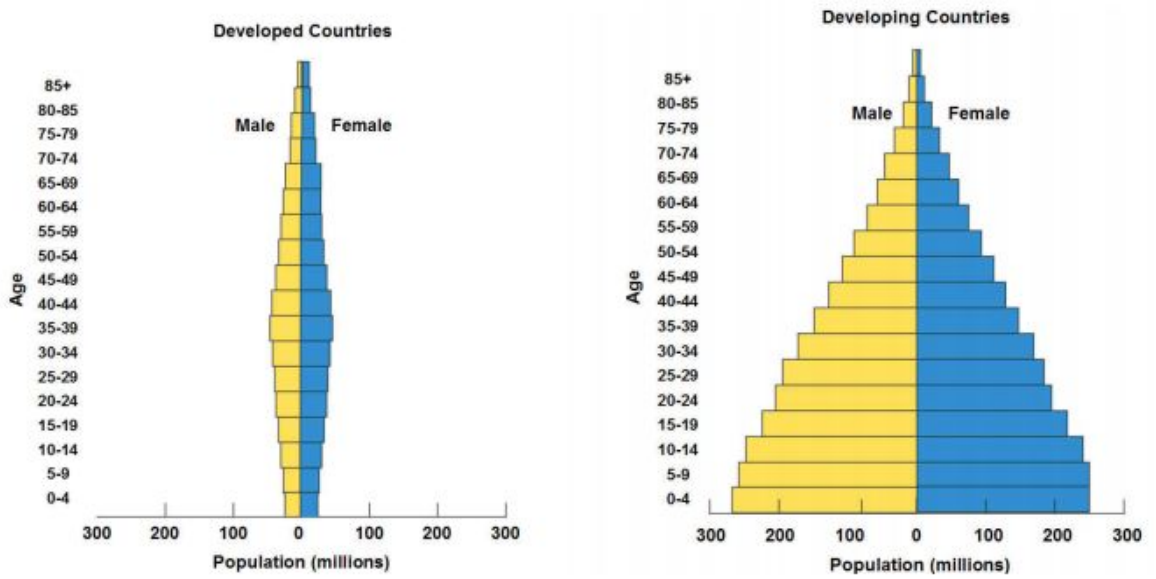
These diagrams help to determine how a country's population will grow. Take a look at the two structures below:



2. Which of the structures above shows imminent population growth?

The percentage (or the actual number) of the population that is of reproductive age is the percentage that will be responsible for increasing population, in addition to the percentage that will be reaching reproductive age in the following years. In the diagram to the left, the reproductive population is much smaller and there are fewer children in the age categories below the reproductive age groups. As you might think, the populations of less developed countries are increasing at a greater rate than those of developed countries. In addition, a larger number of malnourished people also live in those developing countries. Almost all the hungry people, 780 million, live in developing countries, representing 12.9 percent, or one in eight, of the population of developing countries. There are 11 million people undernourished in developed countries (FAO, 2018).

3. What are the implications of rapidly growing populations and more malnourished people in developing countries? What might a country do to decrease population growth? What has been done (i.e. China, Thailand, India policies)?

In 1798, Thomas Robert Malthus predicted that short-term gains in living standards would be undermined as human population growth outstripped food production, and create a population crash. However, we have not seen this to be the case. Over the last half-century, world population doubled while food supply tripled, even as land under cultivation grew by only 12%

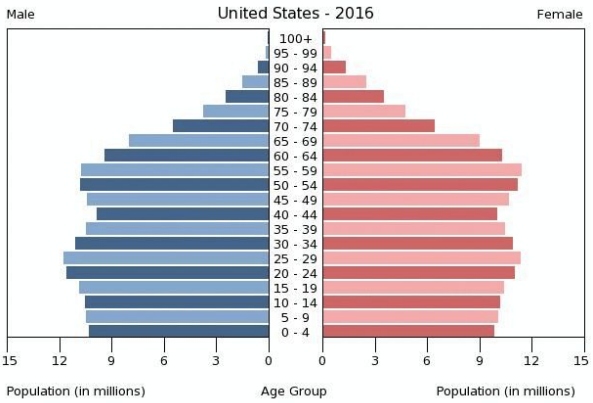
(FAO, 2012). It is by raising productivity, or getting more output from existing resources, that has been driving growth in global agriculture, and what has proven Malthus wrong. In fact, at the global level, the long-run trend since at least 1900 has been one of increasing food abundance—in inflation-adjusted dollars, food prices fell by an average of 1% per year over the course of the 20th Century - See more at: http://www.choicesmagazine.org/choices-magazine/submitted-articles/productivity-growth-in-global-agricultureshifting-to-developing-countries#sthash.G3Uw6q0Z.dpuf

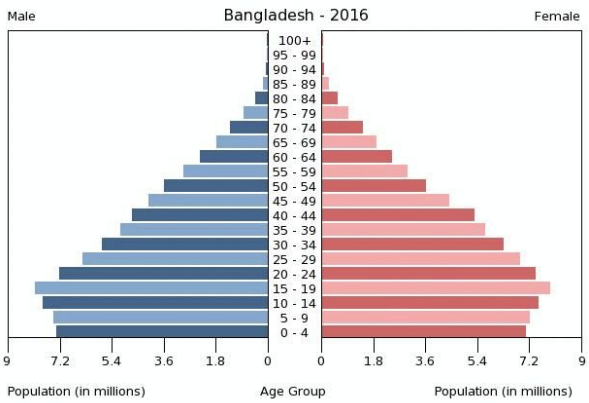
Read the three statements below:

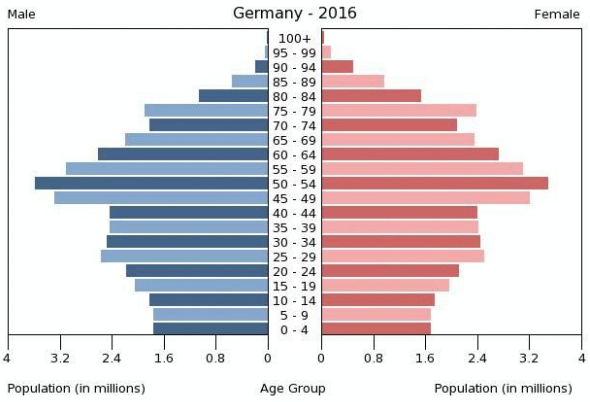
a. Agriculture employs over 1.3 billion people throughout the world, or close to 40 percent of the global workforce.
b. In about 50 countries, agriculture employs half of the population, and even 75 percent in the poorer nations.
c. Agriculture is the world's largest provider of jobs.
http://www.momagri.org/UK/agriculture-s-key-figures/With-close-to-40-%25-of-the-global-workforce-agriculture-is-theworld-s-largest-provider-of-jobs-_1066.html

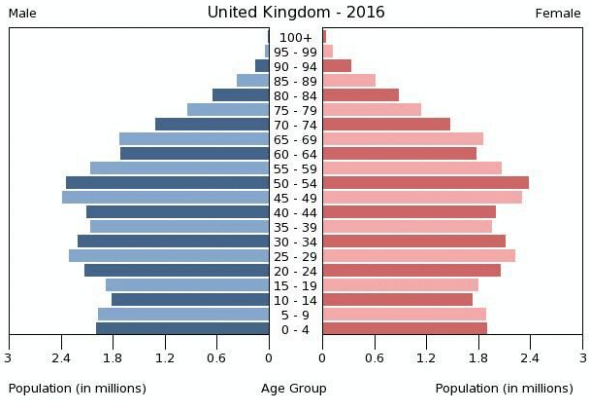
4. In light of the predictions of Malthus, the realities of food production since 1900, including the Green Revolution and new technologies which include genetic modification of various types, and precision agriculture techniques, what is your prediction about food production in the next 30 years? What strategies can we continue to use, or develop, to meet the needs of growing populations and changing demographics?

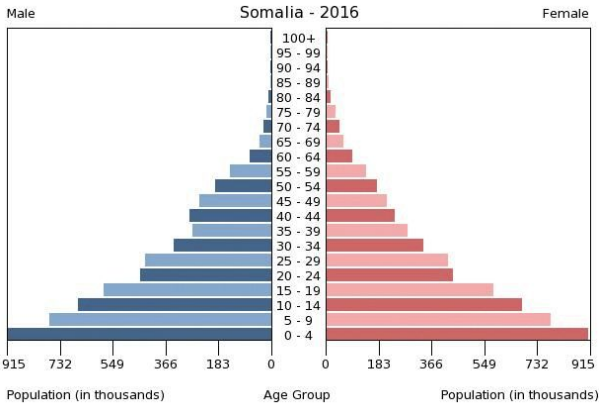
Look at the age structures below to predict the growth of the populations in those countries as high, medium, low or negative.

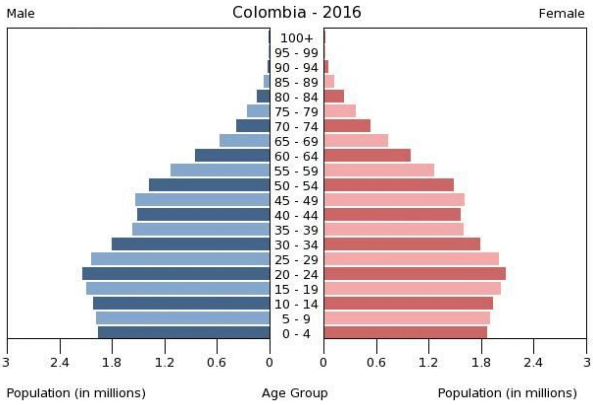


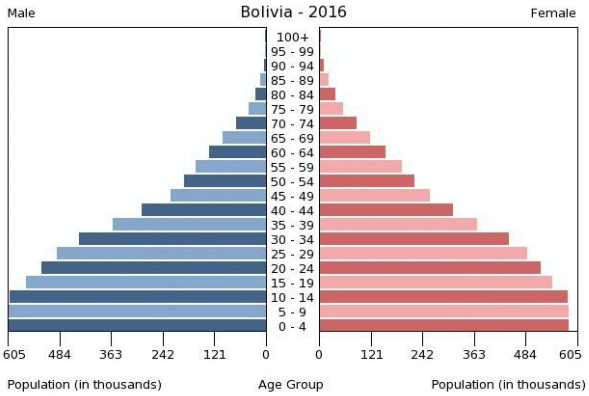












Visit the site: https://www.indexmundi.com to compare the actual numbers of individuals in each age group.

Additional resources:

Hans Rosling - Religion and babies
https://www.ted.com/talks/hans_rosling_religions_and_babies

Hans Rosling - Global Population Growth
https://www.ted.com/talks/hans_rosling_on_global_population_growth

Reflection

1. Looking at the countries that have the largest potential for population growth, what are the causes of their large population growth?

2. Are these causes related to resource availability?

3. What are the ecosystem limits?

4. What can humans do to address those limitations?

Assessment

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. Determine whether the age structure pyramid predicts population growth and if human populations are limited by resource availability based on the economic status of the country.

Rubric for assessment

Skill	Beginning	Satisfactory	Exemplar
Analyze and interpret data to provide evidence of whether resource availability affects human population growth.	Analysis includes some data that provides evidence that resource availability either does or does not affect human population growth.	Analysis includes specific age structure data that provides evidence that resource availability either does or does not affect human population growth.	Analysis includes data comparison across two or more different countries and includes interpretation of the predictive ability of the age structure diagram and that provides evidence that resource availability either does or does not affect human population growth.

Rubric for student self-assessment

Skill	Yes	No
I analyzed data from age structure pyramids to predict human population growth.		

I interpreted data from age structure pyramids to provide evidence that resource availability either does or does not affect human population growth.		

Lesson 3: Demographic Transition - Teacher

Essential Questions: *What demographics change as economies develop? How does demographic transition affect the kinds of foods and resources demanded?*

DCI (Standard)

MS-ESS3.C: Human Impacts on Earth's Systems	
Performance Expectation	**Classroom Connections**
MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems.	Students construct an argument from evidence they research to support or refute that growth of human populations impacts Earth's systems for food production.
Science & Engineering Practice	
Engaging in Argument from Evidence ● Construct an oral and/or written argument supported by empirical evidence and scientific reasoning to support or refute a model for a phenomenon.	Students identify evidence to support the claim from the given materials, including: i. Changes in the size of human population(s) in a given region or ecosystem over a given timespan. ii. Per-capita consumption of resources by humans in a given region or ecosystem over a given timespan.
Disciplinary Core Idea	
ESS3.C: Human Impacts on Earth Systems ● Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	Students research effects of increased production/consumption of food and how economic changes lead to changes in consumption.
Cross Cutting Concept	

Influence of Science, Engineering, and Technology on Society and the Natural World ● All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.	Students include the ways engineered solutions have altered the effects of human activities on Earth's systems. What technologies have contributed to the demographic transition modeled in this diagram? Students investigate the technology that has been developed to reduce human impact on food production systems.

This lesson is designed to follow Lesson 1: *Population Growth* and Lesson 2: *Population Age Structures*. The lessons include information about the same countries and students will get a comprehensive view of the countries by researching the factors that contribute to population growth and the economies. This background does not appear on the student handout, but can be shared with students or not, depending on the teacher objectives. Students will research to construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems.

Supplemental materials

This video: *A global food crisis may be less than a decade away* with Sara Menker https://www.youtube.com/watch?v=OzA6jRYjVQs helps to describe a different way of framing the question "How do we feed 9 billion people in 2050?" Sara Menker uses calories and lists which countries are net calorie exporters and which are importers of calories. It helps to explain the economic conditions that lead to demographic transition. Her group has created a website See also: https://populationeducation.org/what-demographic-transition-model/ for additional explanation about the demographic transition model. This website also provides a case study for each stage of the model 2-5.

Background

By 2050 the world's population will reach 9.8 billion, about 30 percent higher than today's population. Nearly all of this population increase will occur in developing countries. Urbanization will continue at an accelerated pace, and about 70 percent of the world's population will be urban (compared to 49 percent today). In order to feed this larger, more urban population, food production must increase by 60-70 percent. Urbanization brings with it changes in lifestyles and consumption patterns. In combination with income growth it may accelerate changes in the diets of people in developing countries. Currently, these populations depend heavily on grains: maize, wheat and rice. While the shares of grains and other staple crops will be declining, those of vegetables, fruits, meat, dairy, and fish will increase. In response to this change, these groups will be increasingly buying food from markets where there is more of a concentration on secondary consumers (animals that eat the grains). However, rural areas will still be home to the majority of the poor and hungry for quite some time. Currently, one billion people cannot even satisfy their basic needs in terms of food energy.

http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf
Feeding these additional billions by 2050 is a formidable challenge, with tighter resource constraints (land, water, soil), the demand to limit agriculture's ecological footprint and the impact of climate change. Many have argued that distribution is the problem and if we could solve that, there is enough production to feed the world population now (http://pdf.wri.org/great_balancing_act.pdf). Current global food availability is not sufficient to feed the world in 2050, even if all the food calories available in the world today were equally distributed across the projected population in 2050. With the changes that will be demanded by a growing urban population (as described above), this idea is not feasible. Boosting farm productivity is an essential instrument to alleviating poverty and reducing hunger.
Reducing food waste and encouraging less resource-intensive diets in developed countries (particularly lower meat consumption) are desirable goals, but they do not reduce the need to invest in increasing agricultural production and improving agricultural productivity in both developed and developing countries.

1. Choose one of the countries below to evaluate. Estimate what stage of transition the country is in on the DT model. Use evidence when explaining the position on the model.

		United States	Bang-ladesh	UK	Germany	Som-alia	Colum-bia	Bolivia
Birth rate	1990	17/1000	35/1000	14/1000	11/1000	48/1000	26/1000	35/1000
	2018	12/1000	19/1000	12/1000	9/1000	39/1000	16/1000	22/1000
Death rate	1990	9/1000	10/1000	11/1000	12/1000	20/1000	6/1000	13/1000
	2018	8/1000	5/1000	9/1000	12/1000	13/1000	6/1000	6/1000
Natural increase*	1990	0.8%	2.5%	0.3%	negative rate of growth	2.8%	2%	1.2%
	2018	0.4%	1.4%	0.3%	negative rate of growth	2.6%	1%	1.6%

Stage on Demo Transition		*Stage 5*	*Stage 3 or 4*	*Stage 5*	*This model does not show*	*Stage 2 or 3*	*Stage 4*	*Stage 3*

* Natural increase = (BR – DR) * 100 (expressed as a percent)
1000

2. What is the status of freshwater and land use in the country you chose?
    a. Use ciafactbook.gov to find land use for agriculture data and amount of irrigated land (Geography)
    b. What is the percent of the population working in agriculture? (Economy)
    c. Research other sites to find the amount of freshwater resources and compare to the population. (http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en Internal renewable water resources)
    d. Search for domestic water use per capita: http://chartsbin.com/view/1455
    e. Use https://www.nationalgeographic.com/what-the-world-eats/ to determine caloric consumption of food for each country.

Students should be encouraged to choose other stats to help them determine what factors contribute to ecosystem impacts. Middle school students should use evidence to support their explanations.

United States

Land use for agriculture	9,147,593 sq km*44.5% = 4,070,679 sq km
Amount of irrigated land	264,000 sq km
% working in Ag	160.4 million*0.7%=1.13 million
Freshwater resources	2818 $10^9 m^3$
Domestic water use per capita	1,550m^3/year
Problems	
Population	329,256,465
Population below the poverty line	15.1% or 49.7 million
Calories consumed	3641 kcal/person

Notes: Third largest country in terms of population.

Bangladesh

Land use for agriculture	130,170 sq km*70.1%=91,249 (most arable)
Amount of irrigated land	53,000 sq km
% working in Ag	66.64 million*43%=28.7 million
Freshwater resources	105 $10^9 m^3$
Domestic water use per capita	224 m^3/year
Problems	
Population	159,453,001
Population below the poverty line	24% or 38,268,720
Calories consumed	2270 kcal/person

Notes:

UK

Land use for agriculture	241,930 sq km*71%=171,770 sq km
Amount of irrigated land	950 sq km
% working in Ag	33.5 million*1.3%=435,500
Freshwater resources	145 $10^9 m^3$
Domestic water use per capita	212.5 m^3/year
Problems	
Population	65,105,246
Population below the poverty line	15% or 9.8 million
Calories consumed	3413 kcal/person

Notes:

Germany

Land use for agriculture	348,672 sq km*48%=167,363 sq km
Amount of irrigated land	6500 sq km

% working in Ag	45.9 million*1.4%=642,600
Freshwater resources	107 $10^9 m^3$
Domestic water use per capita	392.3 m^3/year
Problems	
Population	80,457,737
Population below the poverty line	16.7% or 13,334,442
Calories consumed	3539 kcal/person

Notes:

Somalia

Land use for agriculture	627,337 sq km*70.3%=441,017 sq km (mostly pasture)
Amount of irrigated land	2000 sq km
% working in Ag	4.154 million*71%=2.95 million
Freshwater resources	6 $10^9 m^3$
Domestic water use per capita	378 m^3/year
Problems	Desert, drought
Population	11.26 million
Population below the poverty line	73% or 8.2 million
Calories consumed	1695 kcal/person

Notes:

Colombia

Land use for agriculture	1,038,700 sq km*37.5%=389,512.5 sq km (mostly pasture)
Amount of irrigated land	10,900 sq km
% working in Ag	25.76 million*17%=4.3792 million
Freshwater resources	2,145 $10^9 m^3$

Domestic water use per capita	308 m^3/year
Problems	Five River basins Water is used for hydropower Demand for water outstrips the inadequate capacity caused by insufficient infrastructure Extensive pollution from industrial and agricultural activities and lack of sewage treatment.
Population	48,168,996
Population below the poverty line	28% or 13.4 million
Calories consumed	2690

Notes:

Bolivia

Land use for agriculture	1,083,301 sq km * 34.3%=371,572 sq km (mostly pasture)
Amount of irrigated land	3000 sq km
% working in Ag	5,719,000*29.4%=1.681 million
Freshwater resources	$303.5\ 10^9 m^3$
Domestic water use per capita	234 m^3/year
Problems	Fresh water contamination by sewage and deforestation (leading to sediment pollution)
Population	11 million
Population below the poverty line	39% or 4.29 million
Calories consumed	2100 kcal/person

Notes: Bolivia is one of the poorest countries in the Western Hemisphere

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the demographic changes in their city, state (i.e. a business invests in a new plant (Honda or Toyota) or a plant shuts down (Kodak or a steel mill).

ii. **Students with special needs (language/reading/auditory/visual)**: See extra support below.
iii. **Extra support**: Video: *Population pyramids: Powerful predictors of the future - Kim Preshoff* (https://www.youtube.com/watch?v=RLmKfXwWQtE) This video helps to combine this lesson and Lesson 2: Population Age Structures. There is also a lesson plan here: https://ed.ted.com/lessons/population-pyramids-powerful-predictors-of-the-future-kim-preshoff
iv. **Extensions**: Students can research previous economic events that have affected the population changes (i.e. post-WWII baby boom in U.S., Russian governmental changes after the fall of Communism, etc.)

Reflection

1. As a country develops, according to this model, what trends do you see in population statistics?

Possible answers: death rates fall first, then birth rates; an initial rise in population growth rate, then a drop

2. As a country develops, what happens to the kinds of foods people eat (How do eating habits change)? See: https://www.nationalgeographic.com/what-the-world-eats/

Possible answers: people generally begin to eat at higher levels on the energy pyramid: i.e. instead of eating grains or plant-based foods, people being to eat animals that eat the plant-based foods (beef, chicken, pork) depending on the culture/religion

3. What negative effects might those eating habits have on the environment, the economy, food production?

Possible answers: animals that eat plant-based foods need grazing land, larger amounts of water and higher amounts of waste; meat is more expensive than plant-based foods; food production becomes more specialized by concentrating livestock operations and grain operations in different areas; however, efficiencies are increased and food generally has a higher protein content, lowering malnutrition.

4. How might humans increase crop production without increasing water use or amount of crop land?

Possible answers: use of biotechnology, advanced irrigation techniques like drip irrigation that will lower the amount of water lost to evaporation; precision ag techniques like soil testing and using soil amendments only where needed, reducing fuel use, etc.

5. What technologies have contributed to the demographic transition modeled in this diagram?

Possible answers: tractors and harvesters have lowered the number of people needed to grow food; better health care and access to drugs for treatment of and curing diseases; access to education for women, etc.

Assessment

Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems. Refer to the demographic transition model and the data you researched about one country and its resource use.

Rubric for assessment

Skill	Beginning	Satisfactory	Exemplar
Apply scientific reasoning, or theory to link evidence to the claims and assess the extent to which the reasoning and data support the explanation or conclusion.	No reasoning provided to link evidence to the claim that human populations impact Earth's systems.	Reason is applied and linked to evidence that human populations impact at least one of Earth's systems.	Scientific reason is applied and linked to specific evidence to support or refute that humans impact multiple systems of the Earth.

Rubric for student self-assessment

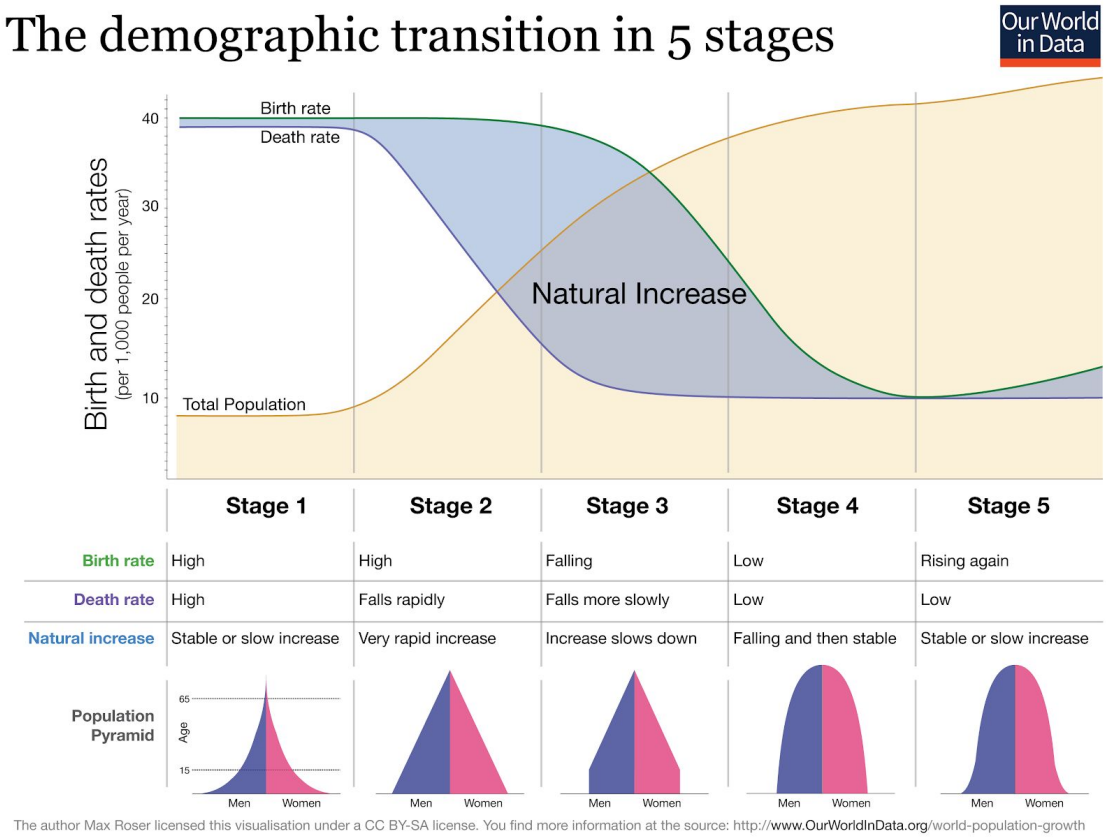
Skill	YES	NO
I provided a reason to support the claim that human populations impact Earth's systems		
I provided evidence to support the claim that human populations impact Earth's systems.		
I listed the systems of the Earth that human populations impact.		

Lesson 3: Demographic transition-MS

Essential Questions: *What demographics change as economies develop? How does demographic transition affect the kinds of foods and resources demanded?*

Once a country begins to industrialize or as its economy develops, there are changes that occur in the demographics or statistics of the country. These statistics include birth rate, death rate, infant mortality and average income.

The Demographic Transition (DT) model is pictured below. Take a few moments to make observations about what is happening during each phase of the model.



https://ourworldindata.org/wp-content/uploads/2013/05/Demographic-TransitionOWID-with-pyramids-1.png

1. Choose one of the countries below to evaluate. Estimate what stage of transition the country is in on the DT model. Use evidence when explaining the position on the model.

		United States	Bang-ladesh	UK	Germany	Som-alia	Colom-bia	Bolivia
Birth rate	1990	17/1000	35/1000	14/1000	11/1000	48/1000	26/1000	35/1000

	2018	12/1000	19/1000	12/1000	9/1000	39/1000	16/1000	22/1000
Death rate	1990	9/1000	10/1000	11/1000	12/1000	20/1000	6/1000	13/1000
	2018	8/1000	5/1000	9/1000	12/1000	13/1000	6/1000	6/1000
Natural increase*	1990	0.8%	2.5%	0.3%	negative rate of growth	2.8%	2%	1.2%
	2018	0.4%	1.4%	0.3%	negative rate of growth	2.6%	1%	1.6%
Stage on Demo Transition								

* Natural increase = $\frac{BR - DR}{1000} * 100$ (expressed as a percent)

2. What is the status of freshwater and land use in the country you chose?

a. Use ciafactbook.gov to find land use for agriculture data and amount of irrigated land (Geography)
b. What is the percent of the population working in agriculture? (Economy)
c. Research other sites to find the amount of freshwater resources and compare to the population. (http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en)
d. Use https://www.nationalgeographic.com/what-the-world-eats/ to determine caloric consumption of food for each country.

Reflection

1. As a country develops, according to this model, what trends do you see in population statistics?

2. As a country develops, what happens to the kinds of foods people eat (How do eating habits change)? See: https://www.nationalgeographic.com/what-the-world-eats/

3. What negative effects might those eating habits have on the environment, the economy, food production?

4. How might humans increase crop production without increasing water use or amount of crop land?

5. What technologies have contributed to the demographic transition modeled in this diagram?

Assessment
Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth's systems. Refer to the demographic transition model and the data you researched about one country and its resource use.

Rubric for assessment

Skill	Beginning	Satisfactory	Exemplar
Apply scientific reasoning, or theory to link evidence to the claims and assess the extent to which the reasoning and data support the explanation or conclusion.	No reasoning provided to link evidence to the claim that human populations impact Earth's systems.	Reason is applied and linked to evidence that human populations impact at least one of Earth's systems.	Scientific reason is applied and linked to specific evidence to support or refute that humans impact multiple systems of the Earth.

Rubric for student self-assessment

	YES	NO
I provided a reason to support the claim that human populations impact Earth's systems		
I provided evidence to support the claim that human populations impact Earth's systems.		
I listed the systems of the Earth that human populations impact.		

Lesson 4: Farming for the Future - Teacher

Essential Questions: *How many people farm in the world? What are the practices that the majority of global farmers use?*

DCI

MS-LS2.A: Interdependent Relationships in Ecosystems

Performance Expectation	Connections to Activity
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. ● [CS: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]	Students engage in a subsistence farming simulation in order to analyze and interpret data collected through the actions of their group.
Science & Engineering Practice	
Analyzing and Interpreting Data ● Analyze and interpret data to provide evidence for phenomena.	Students organize the data they collect (e.g., using tables, graphs, and charts) to allow for analysis and interpretation of relationships between resource availability (yield from their fields) and humans in their village, including: populations (e.g., sizes, and growth information) of organisms as a function of resource availability and growth (malnutrition effects) on individual organisms as a function of resource availability (yield).
Disciplinary Core Idea	

LS2.A: Interdependent Relationships in Ecosystems ● Growth of organisms and population increases are limited by access to resources.	Students compare yields and malnutrition data to see the result of limits to resources.
Cross Cutting Concept	
Cause and Effect ● Cause and effect relationships may be used to predict phenomena in natural or designed systems.	Students compare their data to see the effect of less food than required on the health of the population (i.e. malnutrition).

Background

Over 43% of the world labor force in 1991, was dedicated to agriculture, but as of 2018, it is down to about 25%, with the number much higher in less developed countries, but much lower (about 2%) in more developed countries like the United States. Mechanization and technology has accounted for much of the change, yet there are many countries with over 50% of their labor force still dedicated to a subsistence farming method that has been practiced for thousands of years. This method relies on growing enough food for the family or village to get them to the next growing season, and is not always successful.

The infrastructure that exists in the United States that allows farmers to sell their grain or livestock in one state that will be made into food products that will be distributed across the region or even the world does not exist in less developed countries. In those countries, access to electricity can be a large barrier to drying grains so they do not spoil. Trucks and roadways may be lacking that would allow for travel to a regional market. Sometimes, consumers like products from other regions better (see: Rice Farming in Afie, Ghana: https://www.youtube.com/watch?v=UrddBks41IY).

Students engage in this simulation to see the differences between commodity farming as it exists in the US and subsistence farming as it may exist in a less developed country. They will collect data about yields and malnutrition, then analyze the data to determine if human populations are limited by their resources and how humans have overcome some of those limitations. Students will participate in groups of 3-5 to form a village. They will work together to make decisions about what crops to plant and where to plant them.

Materials

One four-sided die for each group

One set of instructions for each group
Data sheets for each group
One set of impact cards for Round 1 and Round 2 for the entire class
One set of impact cards for Round 3 for the entire class
One Effects of Malnutrition chart for each group
Photos of the crops that are being planted. (Many students are unfamiliar with these crops.)

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the farming methods used in their town, county or state.

ii. **Students with special needs (language/reading/auditory/visual)**: For students who are not interested in working in groups or who do better on their own try *3rd World Farmer* simulation (https://3rdworldfarmer.org/) o see how successful they might be.

iii. **Extra support**: Video: *Subsistence Farming* (https://www.youtube.com/watch?v=jlBu-qaNMMg) This video has no dialogue, but shows two of the labor practices necessary to subsistence farming: clearing a weed patch and planting rice.

iv. **Extensions**: Students can compare subsistence farming methods to those used in commodity farming most often in the United States. This text reading gives some background. https://www.opengeography.org/ch-6-food-water-and-agriculture.html with the following addendum about GMO crops: long-term studies on public health have not been confirmed yet. See: http://nas-sites.org/ge-crops/category/report/ which has found no negative effects of GM crops on health. Or, students can investigate methods being used to improve subsistence farming, [i.e. Agroforestry (http://www.worldagroforestry.org/) *Dreams come true: the benefits of agroforestry*- using trees intercropping to improve soil (https://www.youtube.com/watch?v=PQXpPmeDh3Q&t=1s), *Push Pull Agriculture* - striga weed, desmodium and napier grass, used along with maize; stem borer and wasps produced by the International Center for Insect Physiology and Ecology (https://www.youtube.com/watch?v=XY_m-gemNMw) *Warehouse Receipts Systems* to store and sell grain (https://www.youtube.com/watch?v=n1GG3MJSNSw)]

Reflection

1. How successful were you at growing enough food for your village?

   Possible answers: Answers will vary and are due to chance; ask students how the answers are so different between groups...all villages may not be in the same region, the weather conditions and impact cards will not be the same

2. How is this simulation realistic? Not realistic?

   Possible answers: Realistic: Much of farming is up to the weather and the choice of crops, Unrealistic: Education will vary among villagers and markets may be more accessible for some than others; impact cards are skewed negatively in the first two rounds, but improvements are possible in the third

3. What suggestions would you recommend to an NGO to provide for your village?

Possible answers: Provide education so all can read, provide methods that rely on available technology (cell phones), provide a forum to share village successes, provide birth control to lower population growth, etc...

4. Describe 3 specific differences between this farming simulation and commodity farming as it is practiced in the United States.

Possible answers: Tractors and harvesters are used in US (more access to fuel and machinery), access to fertilizer and pesticides, soil characteristics are different, some farmers plant only one or two crops, do not need to feed the family or village from their fields

5. What can the village learn from the United States?

Possible answers: Villagers may use the information to improve crop selection (GMOs) and crop rotation; Fertilizers and pesticides help improve yield, but can be overused; Soil is a precious resource; Scale and efficiency may be helpful, but will not feed the village directly

6. What can the United States learn from your village?

Possible answers: Working together can help increase yield; Improved methods on small scale may be applied on a large scale; Feeding people locally is possible

7. What did you learn from completing this simulation?

Possible answers: Answers will vary

Assessment

Analyze and interpret your data to provide evidence for the effects of resource availability on humans in your village. Use the questions below to help you with your answer.

1. How does this method of farming with the limitations you encountered, meet the needs of the people using these methods?

Possible answers: It may be able to feed the people in the village without relying on outside sources; It may meet cultural needs (providing work for villagers, keeping people fed, etc)

2. How might the methods of subsistence farming lead to problems that may increase the size of populations in areas where there are using these methods?

Possible answers: If child mortality is high due to high malnutrition and poor sanitation, the likelihood that villagers will have more children to be sure some make it to adulthood will increase; If access to health care is poor, that will affect the child mortality rate; if education is lacking for all (or especially women) the birth rate may increase

3. What new methods might be used? How might those methods impact the ecosystem?

Possible answers: Agroforestry and push pull methods of agriculture will improve soils and allow for raising livestock as the trees will provide fodder; these methods in combination use natural biological properties to help crops to grow without pest problems

4. What are the barriers to using new methods?

   Possible answers: Access to tractors and harvesters; access to electricity and other technology; learning about new methods and gaining access to new crops; unfamiliarity with GMOs and their benefits

5. How might the introduction of technology reduce these barriers?

   Possible answers: It may allow farmers to access information and gain access to markets

Assessment

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. Share the data from your village. Determine whether the availability of food was enough to feed the people in your village. Compare your data to the data of another group to see the similarities and differences.

Rubric for assessment

Skill	Beginning	Satisfactory	Exemplar
Analyze and interpret data to determine similarities and differences in findings.	Data is organized in a table, but no interpretation is included (i.e. no effects of malnutrition, nor an attempt to change the crops planted)	Data is organized and malnutrition data is interpreted; comparison made to one other group's data	Data is organized and malnutrition data is interpreted; comparison is made with two or more other group data to determine the effectiveness of this farming method.

Rubric for student self-assessment

Skill	Yes	No
My group organized data in a table		
I helped the group to interpret data to evaluate malnutrition status		
I compared my group's data with data from other group's to determine the effectiveness of this method of farming		

Lesson 4: Farming for the Future

Adapted from an activity developed by Facing the Future (https://www.facingthefuture.org)

Essential Questions: *How many people farm in the world? What are the practices that the majority of global farmers use?*

Nearly three fourths of all farms worldwide are less than one hectare (about 2.5 acres). Just over ten percent of all farms are between 2.5-5 acres. Only one percent of farms are over 125 acres. (http://www.globalagriculture.org/report-topics/industrial-agriculture-and-small-scale-farming.html)

In Nebraska, the average farm size is 934 acres while the United States has an overall average farm size of 441 acres (USDA, 2015). Different methods of farming are used on the farms in Nebraska and in the United States, than are used in other countries of the world, particularly developing ones.

In groups of 3 - 5, you will make farming decisions as a "village" determining what crops to plant in which of your 10 fields. Your production will be affected by events that are out of your control (I.e. government stability, corruption, weather events)

Instructions

1. Your village has 10 small fields to plant.
2. You must plant at least **three different crops** to ensure a variety of food types and at least **two fields must be protein crops**. Label the fields where you plant each crop on the year 1 plot.
3. Determine your yields based on the weather dice roll: 1, 2, 3, 4 = dry year; 5, 6 = wet year 4. Use a pencil to fill out the worksheet.
5. Choose an impact card, read it aloud, and calculate impact losses. (Some impacts will affect all villages and some will affect only your village.)
6. Determine the effect of malnutrition based on your final total yield and the Effects of malnutrition chart.
7. Repeat activity for year 2 and year 3.

Plot diagram

Label the plot diagram to show which fields are planted with which crops.

Worksheet

Type/crops		**Number of fields**	**Wet yield units**	**Dry yield units**	**Total**
Roots	Yams		70	20	
	Cassava		40	60	
Cereal	Maize		60	30	
	Millet		30	60	
Protein	Groundnuts		50	30	
	Peas		50	30	
				Total yield	
				Impact loss (from card)	
				Total yield after impact	
				Next year's loss from malnutrition	

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				Loss from last year's malnutrition	
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Normal harvest However, failure to rotate crops has lowered your yield. Cassava is very filling, easy to grow and does not require much water, but it depletes soil. Your village reduces units by 60 if you grew 2 or more fields of cassava.	**Normal harvest** However, "rust," a plant disease, affects your village, reducing maize yields to 50 units for a wet year and 30 units for a dry year. Your village calculates the loss of maize yield.
Normal harvest However, your village's food storage has become damp, causing rot in 25% of your yams. Your village calculates the loss in yam yield.	**Flood** River bursts its banks and since your village is located close to the river, your fields are flooded. Your village loses 50 units.
Normal harvest However, there has been political corruption in your village and a local government official has demanded you pay him with food units. Your village loses 40 units.	**Global warming** Temperatures have been rising steadily. Many seeds are temperature sensitive and will not germinate at higher temperatures. Each village loses 50 units.
AIDS Several working-age villagers have contracted HIV/AIDS, reducing the number of villagers available to grow crops. Your village loses 70 units.	**Population growth** More children were born in your village this year, requiring extra food to survive. Your village increases the "next year's loss from malnutrition" line by 40 units.
Normal harvest However, the amount of food you have been producing allows you to sell some to other villages. However, there is not a road to take you to the nearest village. Your village loses 50 units that it could not sell.	**Normal harvest** However, the amount of food you have been producing allows you to sell some to other villages. You take your extra food to the market shared by your neighboring villages, but no one likes the flavor of the maize you grew. They prefer the flavor of an imported variety. Your village loses 30 units if you grew maize.

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Community well After several years of drought, a non-governmental organization (NGO) offers to work with your village to construct a well. Your village's yield increases by 60 units.	**Biofortification** Your village gets new seed that when grown provides more vitamins and minerals than what your current seed provides. Only 400 food units are now needed to prevent malnutrition.
Experimental field You plant a field of maize using compost and drip irrigation. The irrigation water is from a rooftop catchment system, since rain is your only water source. Your village gains 20 units for each maize field planted.	**Digging ditches** You spend several weeks digging contour ditches, which help conserve water and prevent soil erosion. Your village's yield increases by 30 units.
Rotate crops Your village decides to rotate maize and groundnut crops. Groundnuts enrich the soil with nitrogen, doubling the yield of your maize crops. Your village doubles its maize crop units.	**Composting** Your village decides to start using compost and can thus reduce the buying of expensive fertilizers. Your village saves money and is able to increase crop yield by 20 units
Literacy class Several people in your village join a literacy class and, now able to read the directions on a natural pesticide sack, they find you need less than you have been using. Your village gains 10 units because of the money saved on pesticides.	**Health center** A regional health center opens, providing primary and reproductive healthcare to all villages. The health center teaches reproductive health classes. After time, birth rates begin to stabilize and all villages require less food to survive. All villages revise the malnutrition chart so only 400 food units are needed to prevent malnutrition.
Farming collective All the villages form a collective to learn and share sustainable farming practices. Each village's yield increases by 50 units.	**Agroforestry** Your village has begun to plant trees to help provide fertilizer, fodder, firewood and fruit. Your village's yield increases by 40 units.

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If food production falls below 450 units, your village will suffer from malnutrition and illness, affecting the residents' ability to work in the fields the following year. Use this chart to calculate malnutrition in your village based on the total food unit yield for each year.

Food units	**Loss from malnutrition next year**
450 and above	Lose 0 units
400–449	Lose 25 units
350–399	Lose 40 units
300-349	Lose 55 units
250–299	Lose 65 units
0–249	Lose 70 units

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Reflection

1. How successful were you at growing enough food for your village?

2. How is this simulation realistic? Not realistic?

3. What suggestions would you recommend to an NGO to provide for your village?

4. Describe 3 specific differences between this farming simulation and commodity farming as it is practiced in the United States.

5. What can the village learn from the United States?

6. What can the United States learn from your village?

7. What did you learn from completing this simulation?

Assessment

Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. Share the data from your village. Determine whether the availability of food was enough to feed the people in your village. Compare your data to the data of another group to see the similarities and differences. Use the questions below to help you with your answer.

1. How does this method of farming with the limitations you encountered, meet the needs of the people using these methods?
2. How might the methods of subsistence farming lead to problems that may increase the size of populations in areas where there are using these methods?
3. What new methods might be used? How might those methods impact the ecosystem?
4. What are the barriers to using new methods?
5. How might the introduction of technology reduce these barriers?

Rubric for assessment

Skill	Beginning	Satisfactory	Exemplar
Analyze and interpret data to determine similarities and differences in findings.	Data is organized in a table, but no interpretation is included (i.e. no effects of malnutrition, nor an attempt to change the crops planted)	Data is organized and malnutrition data is interpreted; comparison made to one other group's data	Data is organized and malnutrition data is interpreted; comparison is made with two or more other group data to determine the effectiveness of this farming method.

Rubric for student self-assessment

Skill	Yes	No
My group organized data in a table.		
I helped the group to interpret data to evaluate malnutrition status.		
I compared my group's data with data from other group's to determine the effectiveness of this method of farming.		