FOOD SECURITY (HS)

Demographic transition

Focus questions	What demographics change as economies develop? How can a demographic transition impact the variety of food and resources demanded by a population?
Learning target	Students will research country statistics and compare countries.
Vocabulary	Demographic transition, urbanization, birth rate, death rate, growth rate, infant mortality, average income

HS-ESS3.C Human Impacts on Earth's Systems

Performance expectation HS-ESS3-3	**Classroom connection:** Students research land and water use as well as other factors to create a spreadsheet that illustrates the relationships between human populations and the sustainability of human populations.

Science and engineering practices

Using Mathematics and Computational Thinking	**Classroom connection:** Students describe simplified realistic (corresponding to real-world data) relationships between researched variables to indicate an understanding of the factors (e.g., costs, availability of technologies) that affect the management of natural resources, human sustainability, and biodiversity.

Disciplinary core ideas

ESS3.C: Human Impacts on Earth Systems	**Classroom connection:** Students research effects of increased production/consumption of food and the impacts of that increased consumption of food and production of food on ecosystems while meeting the needs of the human population for food.

Cross-cutting concepts

Influence of Science, Engineering, and Technology on Society and the Natural World	**Classroom connection:** Students investigate the availability of technologies to people in various countries; investigate the technologies that have been developed to reduce the human impact of food production systems.

Teacher preparation

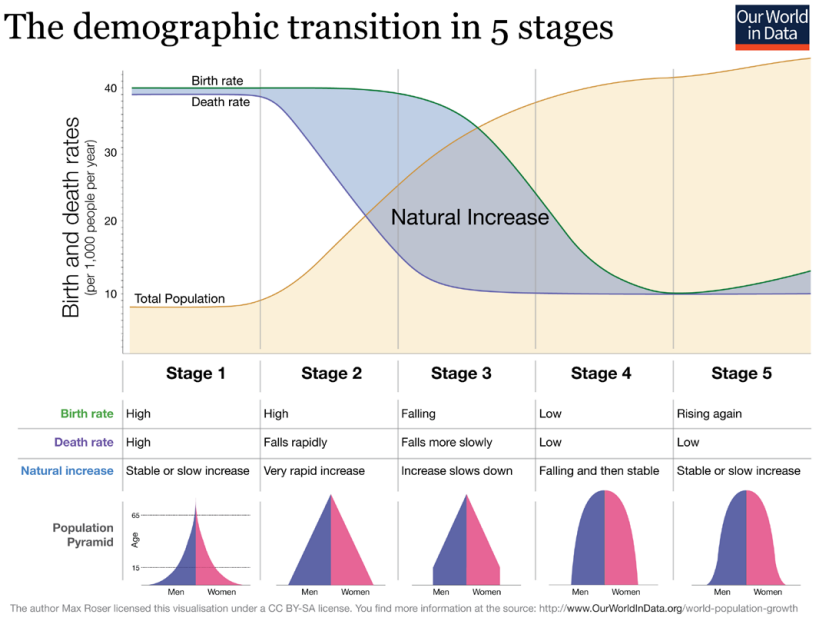
1. Watch this video: A global food crisis may be less than a decade away, a video featuring Sara Menker **youtu.be/OzA6jRYjVQs**. This video helps to describe a different way of framing the question "How do we feed 9 billion people in 2050?" Sara Menker uses calories and lists which countries are net 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 **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. You may want to consider sharing these resources with students to help them think of the relationships among management of natural resources, the sustainability of human populations, and biodiversity in different ways.
2. See the student sheet for additional research students can do to develop their own computational model.
3. See the spreadsheet for an example of a computational model.

This lesson was designed to follow Lesson 2: *Population Growth* and *Population Age Structures*. It includes information about the same countries highlighted in Lesson 2. Students will get a comprehensive view of the countries by researching the factors that contribute to population growth along with the economics in order to create a computational model to describe trends within, among and between countries. This lesson is designed to be assigned to each individual student. They should research information on multiple countries in order to create the spreadsheet to show relationships.

The background below does not appear on the student handout, but is available as a separate student reading.

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 such as 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. **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 (**wri.org/publication/great-balancing-act**). 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. **hbr.org/2016/04/global-demand-for-food-is-rising-can-we-meet-it**

Have students use their handout to research the following aspects. Population growth is determined by the birth rate and death rate within the country.
Growth rate can be calculated by using the formula: ***birth rate/1000 – death rate/1000***

Procedure

1. Evaluate each country below. Determine the birth rate, death rate and growth rate. Estimate what stage of transition the country is in on the Demographic Transition model. Use evidence when explaining the position on the model.

		USA	Bangladesh	UK	Germany	Somalia	Colombia	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
Growth rate*	**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

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

Students should be encouraged to choose other statistics to help them determine what factors contribute to ecosystem impacts. Students need to determine what mathematical relationships exist between factors that describe the countries that have high population growth rates and resources use.

USA

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 109m3
Domestic water use per capita	224 m3/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.

Student handout

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?

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, and 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 or land use?

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.

6. In what other ways have science, engineering, and technology impacted the development of countries to move them into a different stage of the model?

Differentiation

Other ways to connect with students with various needs:

- **Local community:** Students may investigate the demographic changes in their city and/or state (i.e. a business invests in a new plant (Honda or Toyota) or a plant shuts down (Kodak or a steel mill).
- **Students with special needs (language/reading/auditory/visual):** Students may be asked to research information for one or two countries, then combine their information with other students to create a class spreadsheet. Students would then manipulate to determine calculations/mathematical relationships.
- **Extra support:** Teacher may provide background information to students to help them understand the model more fully. Teachers may show this video: Population pyramids: Powerful predictors of the future - Kim Preshoff (**youtu.be/RLmKfXwWQtE**). This video helps to combine this lesson and Lesson 2: Population Age Structures. There is also a lesson plan for discussion with students here: **ed.ted.com/lessons/population-pyramids-powerful-predictors-of-the-future-kim-preshoff**
- **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.). After completing the Demographic Transition activity, find three countries that are in Stage 2 or 3 on the Demographic Transition Model. Visit **fao.org/state-of-food-security-nutrition/en/** to see which regions are suffering from food insecurity. Using **cia.gov/library/publications/the-world-factbook/** or other similar sources, research the economies of the countries that have the largest potential for population growth. What are the causes of food insecurity (be sure to look at multiple aspects, such as infant mortality, education of women and social norms)?

Assessments

Develop a computational model to compare these data points (i.e. compare the data from each country to other countries to determine if relationships exist between countries; and compare the effects of certain pieces of data on others). Include data that were researched as well as those that were supplied. Include other factors that you think may have an effect. *For example: If the growth rate of a population changes, what effect might that have on the number of calories consumed? How about on the use of freshwater per person per year?* (See sample spreadsheet at the end of this document for a beginning/developing/statisfactory/exemplary chart comparing 2 countries.)

- What are the negative impacts of increased production and consumption of food resources?
- How have we tried to address these impacts?

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Use mathematical, computational, and/or algorithmic representations of data. Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units	Spreadsheet created, but no mathematical calculations/ functions applied	Spreadsheet created with data provided and countries compared to one another using mathematical relationships (i.e % more/less, fraction of size, etc)	Spreadsheet created with data provided; additional data added; mathematical functions applied to show relationships between and among data

Rubric for self-assessment

Skill	Yes	No	Unsure
I can create a spreadsheet and enter data in the proper format.			
I can use a spreadsheet to calculate mathematical relationships between the same types of data to compare countries.			
I can use mathematical functions to determine relationships between and among pieces of data.			

Resources used to provide information in this document

- nationalgeographic.com/what-the-world-eats/
- fao.org/nr/water/aquastat/data/query/index.html?lang=en
- chartsbin.com/view/44463
- en.wikipedia.org/wiki/List_of_countries_by_food_energy_intake
- en.wikipedia.org/wiki/Water_resources_management_in_Colombia
- sam.usace.army.mil/Portals/46/docs/military/engineering/docs/WRA/Bolivia/FINAL%20BOLIVIA%20WRA%20COMBINED%2013%20DEC%202004.pdf

Example spreadsheet

Country	Colombia	Bolivia	
Land use for agriculture (sq km)	389,512.50	371,572	*about =*
Amount of irrigated land (sq km)	10,900	3000	*Bolivia 1/3 of Colombia*
% working in Ag	17	29.4	*73% higher*
Freshwater resources (109m3)	2145	303.5	*86% lower*
Domestic water use per capita (m3/yr)	308	234	*32% lower*
Population	48,168,996	11 million	*23% of the size*
Population below the poverty line (%)	28	39	*11% higher*
Calories consumed (kcal/person)	2690	2100	*78% of the calories*