POPULATIONS (HS)

Farming for the future

Focus questions	How many people farm in the world? What are the practices that the majority of global farmers use?
Learning target	Students participate in a simulation of a village reliant on subsistence farming.
Vocabulary	Subsistence farming, infrastructure, commodity farming, overpopulation, overexploitation, climate change

Adapted from an activity developed by Facing the Future (facingthefuture.org)

HS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Performance expectation HS-LS2-7	**Classroom connection:** Students engage in a subsistence farming simulation. Upon completion of the simulation, students evaluate and refine solutions for addressing problems encountered using these methods.

Science and engineering practices

Constructing Explanations and Designing Solutions	**Classroom connection:** Following the simulation, students will design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity (i.e. overpopulation, overexploitation, and climate change)

Disciplinary core ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience	**Classroom connection:** Students develop solutions that help subsistence farmers become more efficient and better producers, compare these methods to commodity farming methods, and explore the effects of food production on the environment.
ETS1.B: Developing Possible Solutions	**Classroom connection:** Students evaluate the cost, safety, and reliability, as well as social, cultural, and environmental impacts, of the proposed solution for a select human activity that is harmful to an ecosystem.

Cross-cutting concepts

Stability and Change	**Classroom connection:** Students refine the proposed solutions by prioritizing the criteria and making tradeoffs as necessary to further reduce environmental impact and loss of biodiversity while addressing human needs. Students evaluate difficulties with the subsistence farming model and barriers to improvements.

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, allowing farmers to sell their grain or livestock in one state to 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 prefer products from other regions (see: youtu.be/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.)

Prior knowledge

Students may want to investigate the crops that they have a choice to grow in the simulation (groundnuts, peas, yams, cassava, maize and millet).

Teacher preparation

Make copies of the materials needed by student groups. Allow time for students to research methods and crops.

After the simulation is completed, ask students to reflect with their group on the guiding questions below:

a. 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).
b. How might the methods of subsistence farming lead to problems that may increase the size of populations in areas where people 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.
c. 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.
d. 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.
e. How might the introduction of technology reduce these barriers?
   Possible answers: Technology may allow farmers to access information and gain access to markets.

Differentiation

Other ways to connect with students with various needs:

- **Local community:** Students may investigate the farming methods used in their town, county or state.
- **Students with special needs (language/reading/auditory/visual):** Students who may not be interested in working in groups or who are motivated by video games, may play 3rd World Farmer simulation (**3rdworldfarmer.org**) to see how successful they might be.
- **Extra support:** Video: Subsistence Farming (**youtu.be/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.
- **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. **humangeography.pressbooks.com/part/food-water-and-agriculture/** with the following addendum about GMO crops: long-term studies on public health have not been confirmed yet. See: **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 (**worldagroforestry.org**) Dreams come true: the benefits of agroforestry-using trees intercropping to improve soil (**youtu.be/PQXpPmeDh3Q**)
  - 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 (**youtu.be/XY_m-gemNMw**)
  - Warehouse Receipts Systems to store and sell grain (**youtu.be/n1GG3MJSNSw**)

Student handout

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. How do stability and change within farming practices play a role in US and subsistence farming systems?

Possible answers: Many people in any occupation do what they have always done since it is predictable and easier. Updated technology and new scientific evidence is not always accessible to all people who practice farming, making change slow to occur if at all.

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

Possible answers: 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

7. 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

8. What did you learn from completing this simulation?

Answers will vary.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	Participated in the subsistence farming simulation; solution to subsistence farming as a method to produce food is vague or missing.	Participated in the subsistence farming simulation; a specific solution or set of solutions that will lessen the impact of subsistence farming and increase food production efficiency is/are included.	Participated in the subsistence farming simulation; a specific set of solutions that will lessen the impact of subsistence farming and increase food production efficiency with priorities for implementation and consideration of barriers to implementation is/are included.

Rubric for self-assessment

Skill	Yes	No	Unsure
I participated in the farming simulation with my group and collected data on yield.			
I can suggest a solution for lessening the impact of subsistence farming on the environment.			
I can suggest a set of solutions for increasing food production efficiency.			
I can prioritize the solutions and predict the barriers to implementing my solutions.			

Year 1

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	

Year 2

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)	
				Loss from last year's malnutrition	
				Total yield after impact	
				Next year's loss from malnutrition	

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)	
				Loss from last year's malnutrition	
				Total yield after impact and malnutrition loss	

Impact cards: years 1 and 2

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.

Impact cards: year 3

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.

Effects of malnutrition

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