# High School Lesson

*Cellular Agriculture using GMO's*

## Description:

Pharmaceutical agriculture is the production of agricultural products from Genetically Modified Organism (GMO) crops, such as making generic medicines from GMO crops or pest-resistant crops for human consumption.

## Agriculture Jobs:

Biological Scientist, Environmental Scientist and Specialist, Food Scientist and Technologist

## Essential Vocabulary:

**Agricultural Development:** providing various assistance to the crop producers with the help of the agricultural resources. Providing protection, assisting in the research sphere, employing latest techniques, controlling pests and facilitating diversity

**Bt Crops:** crops that are genetically engineered to produce the same toxin as Bt (Bacillus thruringiensis) in every cell of the plant, with the goal of protecting the crop from pests

**GMO:** a genetically modified organism, is a plant, animal, microorganism whose genetic makeup has been modified using gene splicing, gene modification or transgenic technology

**Pharmacovigilance:** also known as drug safety, is the pharmacological science relating to the collection, detection, assessment, monitoring, and prevention of adverse effects with pharmaceutical products

**Pest-Resistance:** condition where pests (insects, small animals, mites, weeds, etc.) are able to resist, and therefore do not get affected, by pesticides

| Math Standards | Standards for Math Practice |
|---|---|
| **A1. N. Q. A. 1:** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.<br>**A1. N. Q. A. 2:** Identify, interpret, and justify appropriate quantities for the purpose of descriptive modeling.<br>**A1. F. IF. C. 8:** Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions.<br>**A1. S. ID. B. 4:** Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers). | ☒ MP1: Make sense of problems and persevere in solving them.<br>☐ MP2: Reason abstractly and quantitatively.<br>☒ MP3: Construct viable arguments and critique the reasoning of others.<br>☒ MP4: Model with mathematics.<br>☒ MP5: Use appropriate tools strategically.<br>☒ MP6: Attend to precision.<br>☒ MP7: Look for and make use of structure.<br>☐ MP8: Look for and express regularity in repeated reasoning. |

| Science Standards | Sci. & Eng. Practices | Crosscutting Concepts |
|---|---|---|
| **BIO 1. LS.2-1:** Analyze mathematical and/or computational representations of population data that support explanations of factors that affect population size and carrying capacities of populations within an ecosystem. Examine a representative ecosystem and, based on interdependent relationships present, predict population size effects due to a given disturbance.<br>**BIO 1.ETS 2-1:** Obtain, evaluate and communicate information on how molecular biotechnology may be used in a variety of fields.<br>**BIO 1.ETS 2-3:** Analyze scientific and ethical arguments to support the pros and cons of application of a specific biotechnology such as | ☐ Asking Questions/Designing Problems<br>☐ Developing & using models<br>☐ Controlled investigations<br>☒ Data analysis & interpretation<br>☐ Math & computational thinking<br>☒ Constructing explanations & designing solutions<br>☒ Engaging in argument from evidence.<br>☒ Obtaining, evaluating & communicating information | ☒ Pattern<br>☒ Cause and effect<br>☐ Scale, proportion, and quantity<br>☐ Systems and system models<br>☐ Energy and matter<br>☐ Structure and function<br>☐ Stability and change |

| | | |
|---|---|---|
| stem cell usage, in vitro fertilization, or genetically modified organisms.<br>**EVSC.ESS3-7:** Construct an argument including claim, evidence, and scientific reasoning regarding the impact of the Green Revolution on agricultural practices, food availability, and the environment.<br>**EVSC.ESS3-8:** Research information on the environmental impacts of genetically modified organisms and engage in debate regarding pros and cons of this agricultural technology. | | |

## Teacher Background Knowledge:

Farming is one of the largest occupations in Tennessee. Some farmers grow crops. Crops in Tennessee are soybean, cotton, wheat, and corn. When growing crops farmers have to know the parts of a plant, their functions, and knowledge of what part of a plant that you can eat. They even have to design their field and decide what they are going to plant and how to plant and harvest the crops. Students should be introduced to basic parts of a plant and know their functions because they will be identifying why that is important to know and identifying parts on different plants indigenous to the state of Tennessee.

## Engage:

The human population is growing at an exponential rate. While birth rates add to the population, changing health care and medicinal practices gives longevity to the average life expectancy within the human population.

**Start the lesson.**

Start with video "Are GMO's Good or Bad? Genetic Engineering & Our Food." This video will set up discussion about GMO's and help the teacher assess the student's background knowledge and misconceptions.

Use articles the students will review and report on about population growth and the predication of human population growth.

1. Human Numbers Growing- An Unsustainable Reality
2. National Geographic: As World's Population Booms, Will Its Resources Be Enough For Us?

**Questions:**

1. What are GMO's, and where do you find them?
2. After watching the video, what are your thoughts over GMO's?
3. What are some ethical or financial issues that might be affected by human impact on the environment?

## Explore/ Explanation:

Using population growth and food consumption data, students should be divided up into groups of three and given four sets of data to analyze. The students need to be able to understand that the growth of the population gives rise to the need for more food and medicines, when needed. The population growth is not just in Tennessee, but globally.

1. Watch the video: World Food Crisis by National Geographic
2. Complete the following data sets:
    a. Data Set #1: Crop yields, food prices and diet:
        i. How have these been changing through the years?
    b. Data Set #2: Fertile Soils and Crop Production and Drought
        i. Do we have a lot of fertile soils?
            1. Where are they located?
        ii. Where are droughts happening?

c. Data Set #3: "Water Footprint"- the amount of water used for consuption and productions of services/goods.

   i. Of all water on Earth what fraction is readily available for human use and consumption?

      1. Which countries have the highest water footprints?

      2. Which human activities consume more water?

d. Data Set #4: United States vs Tennessee soil distribution (fertile vs unusable soil).

   i. What type of soils are found in the United States compared to Tennessee?

   ii. Why does Tennessee have good land for farmland (based on the maps)?

## Elaborate:

The need for sustainable food supplies for the people in Tennessee, throughout the country and on a global scale. After studying the data, making graphs, and drawing out important information, student will participate in a debate over GMO's, pest and/or weather resistant crops for consumption, and medicinal needs for the residents in the state of Tennessee.

Students will use their knowledge about the make-up of the population and land throughout the state and defend their side using research and data collected and analyzed. Using the data evaluated from above data sets, articles, and their research

## Evaluate:

Students will write a summary of their research methods, data analysis, and support their argument used in the debate to show mastery of the standards.

Rubric for debate with clear scale and thorough:
http://www.facdev.niu.edu/facdev/_pdf/guide/strategies/classroom_debate_rubric.pdf

Teachers can use a rubric to assess the debate and provide feedback.

## References


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Our numbers. (2017). Retrieved from https://www.populationmatters.org/the-issue/population/?gclid=Cj0KCQjwgb3OBRDNARIsAOyZbxDxcFQgH1vvQnIwqWspjPi53HALSzaMeCLxU5ID2Zye0-jEWtv_XzQaAk0EEALw_wcB

Pest Resistant. (2017). Retrieved from https://www.maximumyield.com/definition/594/pest-resistant

Richardson, J. (2012, August 15). Bt Crops. Retrieved from https://www.sourcewatch.org/index.php/Bt_Crops

What is GMO? (2016). Retrieved from https://www.nongmoproject.org/gmo-facts/what-is-gmo/

# Are GMOs Good or Bad?
# Genetic Engineering & Our Food

1. What are traits? _____

2. What does GMO stand for? _____

3. What is genetic engineering? _____

4. Describe a terminator seed. _____

5. What is a buffer zone and what is its importance? _____

_____

6. What are Bt plants? _____

7. Why would these plants be beneficial to farmers? _____

_____

8. How could plants that attract nitrogen be helpful for the environment? _____

_____

After the video.

1. What makes GMOs different from normal crops and animals?

_____

_____

2. What do good GMOs do?

_____

_____

3. In your opinion, do you think GMOs are bad? Why or why not?

_____

_____

# GMOs Good or Bad?

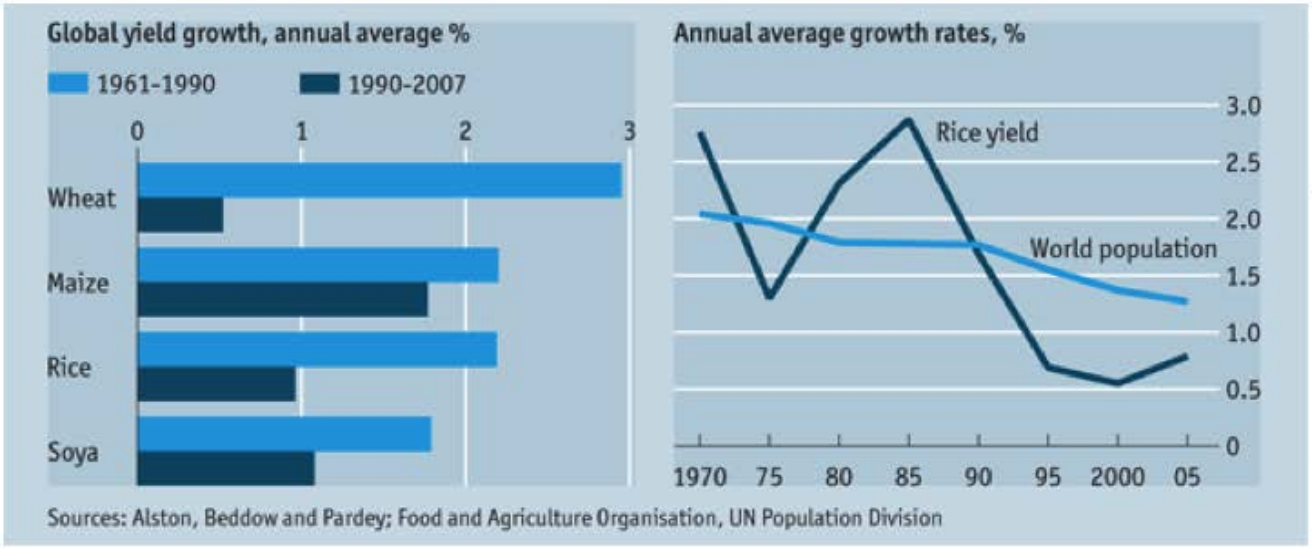
| GMO Good | GMO Bad |
| --- | --- |
| | |

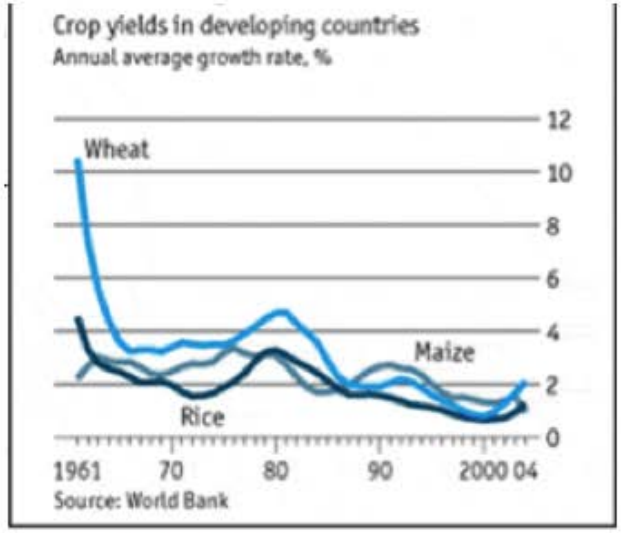
# GMOs and Human Impact on the Environment

| Ethical Implications | Financial Implications |
| --- | --- |
| | |

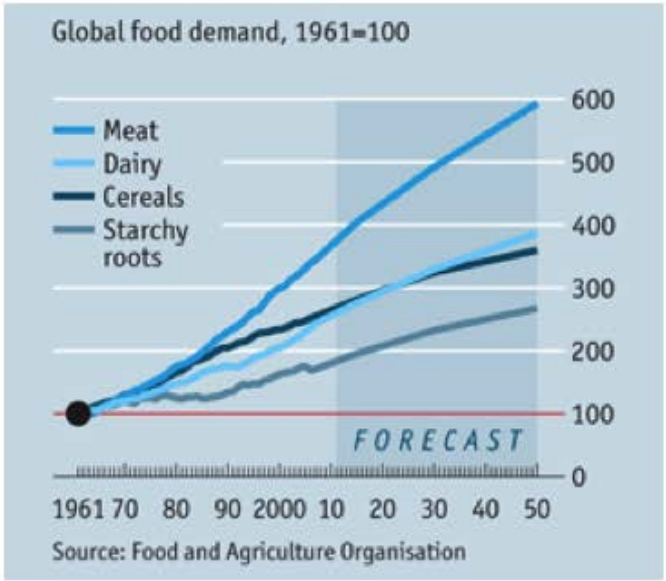
*Source The Economist*

# Data Set #1




*Source: The Economist*

# Data Set #2

## The World's Largest Crops

**2009 PRODUCTION OF:**

| RICE | Millions of tons | World share |
|---|---|---|
| **China** | **197** | **29%** |
| India | 131 | 19 |
| Indonesia | 64 | 9 |
| Bangladesh | 45 | 7 |
| Vietnam | 39 | 6 |
| Thailand* | 31 | 5 |
| Myanmar* | 31 | 4 |
| Philippines | 16 | 2 |
| Brazil | 13 | 2 |
| Japan | 11 | 2 |
| Pakistan | 10 | 2 |
| United States | 10 | 1 |

| WHEAT | | |
|---|---|---|
| **China** | **115** | **17%** |
| India | 81 | 12 |
| Russia | 62 | 9 |
| United States | 60 | 9 |
| France | 38 | 6 |
| Canada | 27 | 4 |
| Germany | 25 | 4 |
| Pakistan | 24 | 4 |
| Australia | 22 | 3 |
| Ukraine | 21 | 3 |
| Turkey | 21 | 3 |
| Kazakhstan | 17 | 3 |

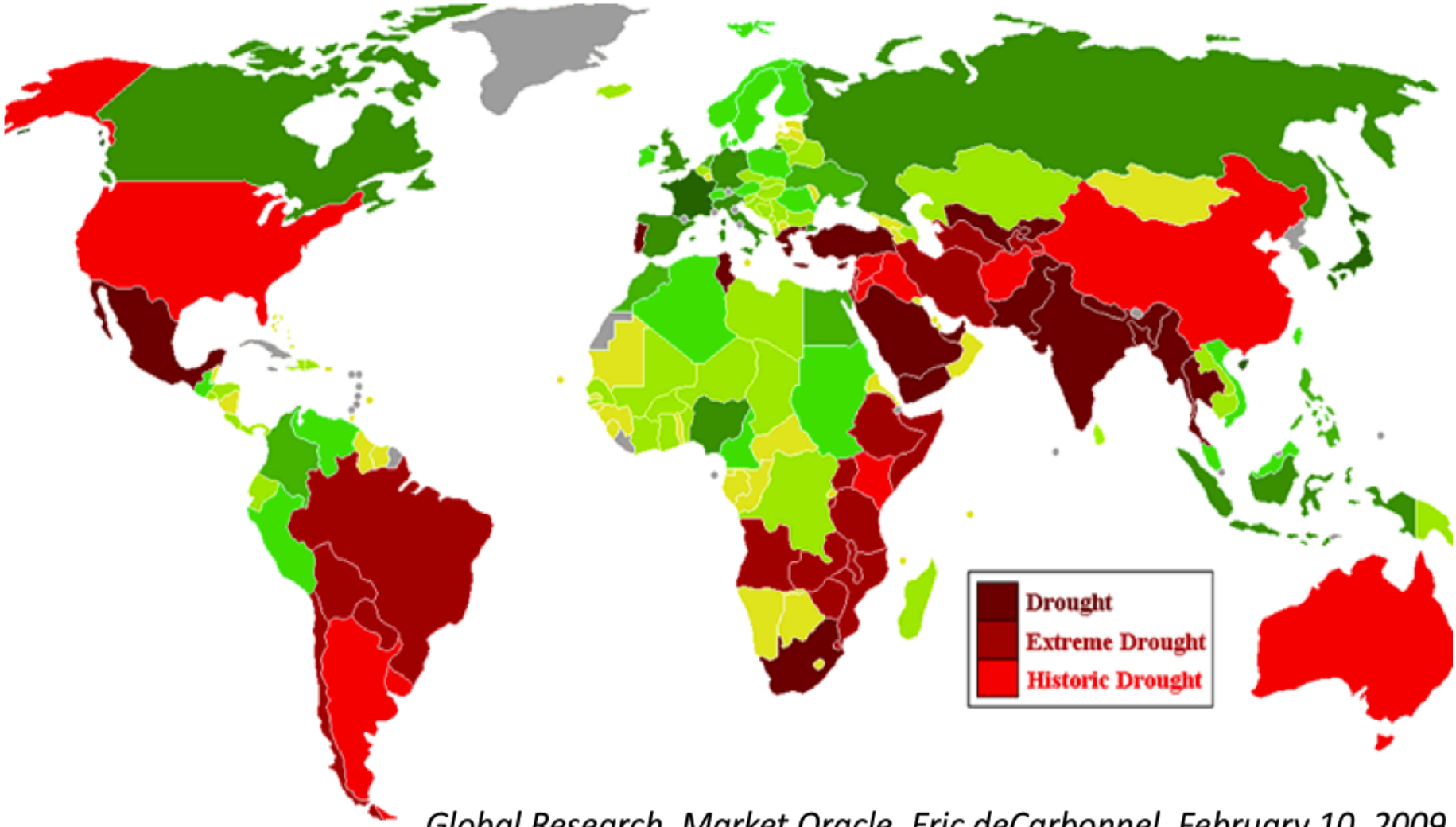
| CORN | | |
|---|---|---|
| United States | 333 | 41% |
| **China** | **163** | **20** |
| Brazil | 51 | 6 |
| Mexico | 20 | 2 |
| Indonesia | 18 | 2 |
| India | 17 | 2 |
| France | 15 | 2 |
| Argentina | 13 | 2 |
| South Africa | 12 | 1 |
| Ukraine | 10 | 1 |
| Canada | 10 | 1 |
| Romania | 8 | 1 |

Source: United Nations Food and Agriculture Organization *2008 production.

THE NEW YORK TIMES

**Data Set #2**

# Drought in 2009




*Global Research, Market Oracle, Eric deCarbonnel, February 10, 2009*

**Historic drought** = Drought levels higher than ever registered before

# Data Set #3

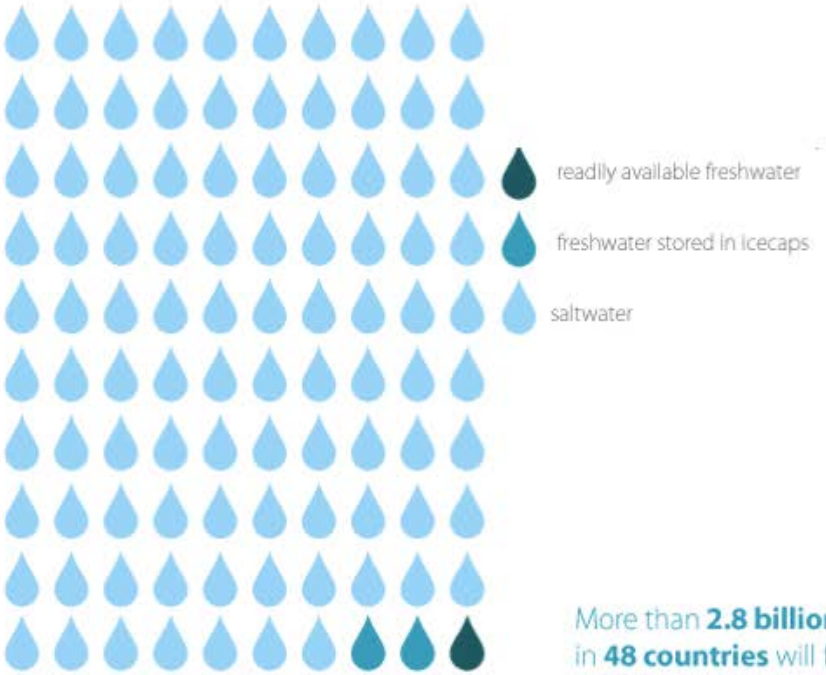
## the global water footprint

The 'water footprint' of a country is defined as the volume of water needed for the production of goods and services consumed by the inhabitants of the country.

**the highest water footprints per capita**

| united states | greece | malaysia | italy | thailand |
|---|---|---|---|---|
| 2,483 $m^3$ per year | 2,389 $m^3$ per year | 2,344 $m^3$ per year | 2,322 $m^3$ per year | 2,223 $m^3$ per year |
| **19%** import dependency | **35%** import dependency | **28%** import dependency | **51%** import dependency | **8%** import dependency |

**amount of freshwater available**




**water footprint of different foods**

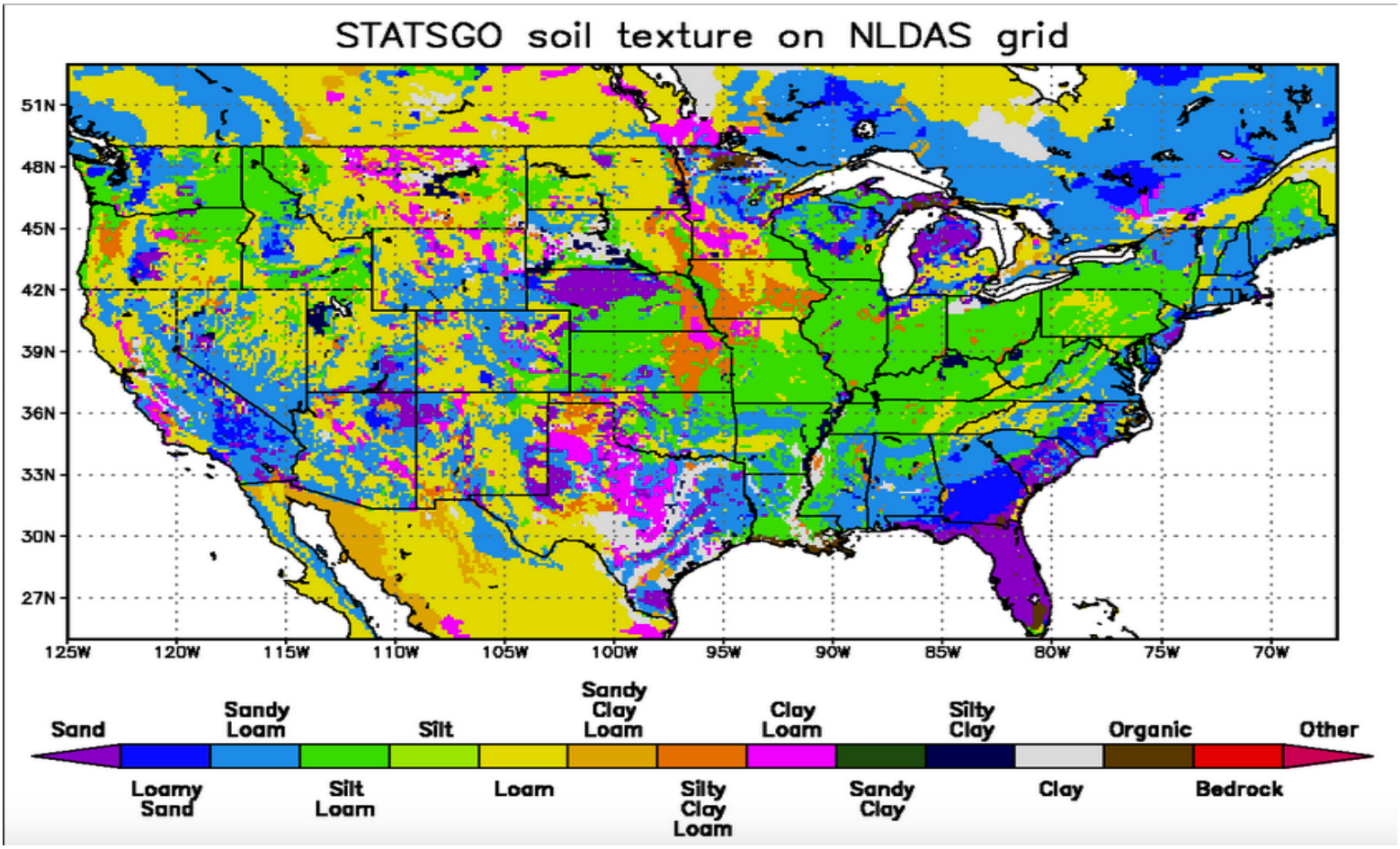
| 24,000 litres | 15,500 litres | 4,400 litres | 1,500 litres | 140 litres |
|---|---|---|---|---|
| 1kg of chocolate | 1kg of beef | 1kg of olives | 1kg of sugar | 1 cup of coffee |

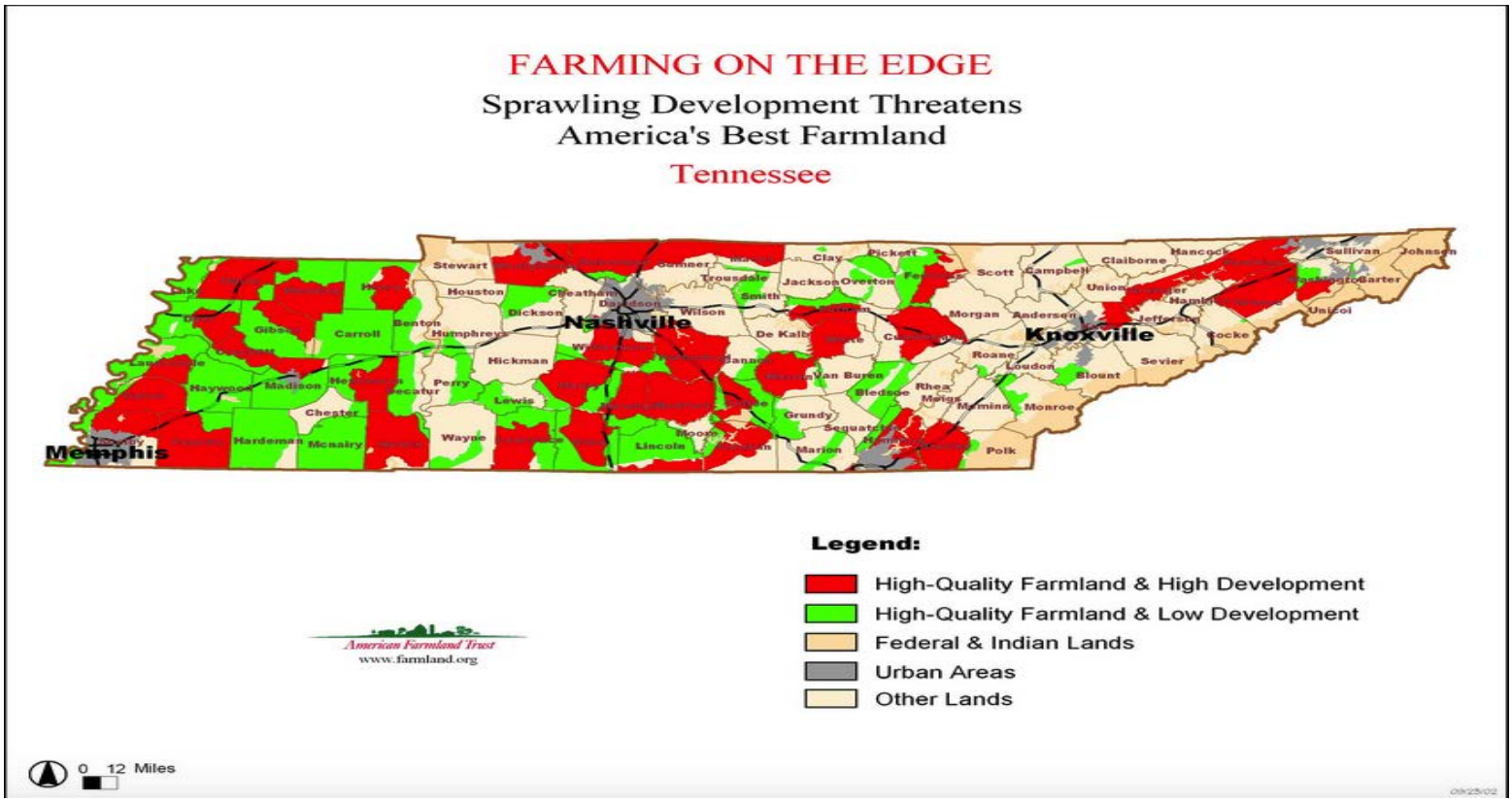
More than **2.8 billion** people in **48 countries** will face water stress or scarcity conditions by **2025.** By the middle of the century, this will have reached almost **7 billion.**

**70%** of existing freshwater is withdrawn for irrigation in agriculture

**Source:** WaterFootprint.org and WWF

# Data Set #4


STATSGO soil texture on NLDAS grid
51N
48N
45N
42N
39N
36N
33N
30N
27N
125W
120W
115W
110W
105W
100W
95W
90W
85W
80W
75W
70W
Sand
Loamy Sand
Sandy Loam
Silt Loam
Silt
Loam
Sandy Clay Loam
Silty Clay Loam
Clay Loam
Sandy Clay
Silty Clay
Clay
Organic
Bedrock
Other


FARMING ON THE EDGE
Sprawling Development Threatens
America's Best Farmland
Tennessee
Nashville
Knoxville
Memphis
Legend:
High-Quality Farmland & High Development
High-Quality Farmland & Low Development
Federal & Indian Lands
Urban Areas
Other Lands
American Farmland Trust
www.farmland.org
0 12 Miles