

Quick Facts

Year	USA Population	World Population	Farming Population
1776	2.5 million people	800 million people	2.25 million (90%)
1900	76 million people	1.6 billion people	29 million (38%)
Today	325 million people	7.5+ billion people	3.2 million (1%)
2050 (estimated)	438 million people	9.7 billion people	TBD

While the world population has grown, the amount of land, water, and other resources has not. This means that farmers have had to learn, adapt and improve to meet the increase in food demand, and they’ve done just that! In part, thanks to efforts of farmers who use sustainable and precision farming methods, food production has more than doubled in this country since the 1970s, soil erosion and use of chemicals has decreased, and resources are being used in a more environmentally-friendly manner. How are farmers doing this? Let’s take a closer look.

What Makes a Successful and Sustainable Farm?

For a farm to be successful, a farmer must balance the equation of the farm, much like a giant scale. On one side of the scale we have everything that can affect the life and quality of the crops or livestock being raised on the farm—weather, soil moisture and nutrient content, and threats like weeds, pests, and diseases. On the other side of the scale is what the farmer can do to increase the productivity and efficiency of crops and livestock, including incorporating irrigation, utilizing technology, and applying fertilizers and herbicides with minimal long-term negative environmental impacts. Farms that are able to balance the two sides of the scale in the most cost-effective way are able to succeed. Fortunately for us, farms that choose sustainable and precision methods can balance the scales, not just for this year, but for many years to come.



Discussion Questions/Activities

1. Think about where you live. How hard do you think it is to feed you, your family, your neighbors, and your town? What would be some problems you might run into trying to feed a small town compared to a big city?
2. Water is our most valuable resource. Almost every day-to-day activity we do requires water at some point—from cleaning and preparing dinner to watering the grass on the baseball field. How many day-to-day activities that require water can you list?
3. Everyone has to balance their scales to be successful. What do you do to enhance and improve outcomes in your life (e.g. school, friends, extracurricular activities)?

PRECISION FARMING— FARMING OF THE FUTURE, NOW!

Picture a farm. Do you see a farmer planting seeds, watering crops, or spraying herbicides by hand? Do you picture a weathered farm veteran on a tractor driving up and down rows of crops painstakingly taking care of corn, soybeans, or tomatoes? These visions may look like a scene from an old movie, and for much of the history of farming in this country that’s how things were done. Farmers today, however, are becoming more aware of how, when, and why they do things on their farms, especially when valuable resources (such as water) or expensive necessities (like fertilizers) are used. More and more farms today are embracing new technology in a new method called “precision farming.”

In the 1900s, nearly half of the population was made up of farmers. Most people lived on a farm, or had some direct connection to farming. Today, that connection is less and less common. Only a very small percentage of our population is involved in growing crops and raising livestock, which is one the reasons farms are growing in size. The majority of our population today lives in urban and suburban areas. With fewer and fewer people producing food, each farmer is responsible for growing and raising enough to feed 165 people.

Another reason farms are growing is because of the efforts to incorporate additional family members into the farming operation. Ninety seven percent of American farms are owned and operated by families, and many of those have been in the same family for several generations. To bring the next generation back to the farm, farmers are expanding and diversifying. In order to grow crops and raise livestock in the best way possible, farmers are embracing new technologies and data.

Some people have been misled to believe that big farms mean “factory farms.” This idea is far from reality. Often, large farms and ranches implement the most innovative processes in sustainability and animal welfare because they have the ability to do so. Large farms and ranches help to keep our food supply reliable, healthy and affordable.



Quick Facts	Average Farm Size	% US Population Living in Cities	Number of People a Farmer Feeds
1900	147 Acres	40%	4
Today	434 Acres	81%	165

Water, Water Everywhere

Possibly the single most important resource on a farm is water. Plants need water to grow and flourish; without water they shrivel and die. In traditional farming methods during periods of drought or low rainfall, fields would be irrigated with water to keep the plants healthy and strong. Without the aid of precision agriculture, it is difficult for farmers to identify specific plots within the field that require more moisture than others. As a result, the entire field is typically watered. While this is an effective way to irrigate fields, it also wastes water.

Picture this instead—at strategic points all through the fields, moisture and nutrient sensors are placed. These sensors are not only hooked into the irrigation system, but they also continuously send data to computers in the cloud about their section of the field. After the computers crunch the numbers, the precise amounts of water and fertilizer are sent to the irrigation system. Now instead of watering the entire field once a week, each part of the field (even down to a single plant) can be watered perhaps every 30 minutes in small, precise doses. This uses significantly less water, helps each plant receive the water, saves the farmer money, and wisely utilizes our natural resource. Now that's precision farming!

Genetic Modification for Better Food

Genetic modification has been a part of farming since the dawn of humanity. At first there were happy accidents when a plant with stronger characteristics survived to create the next generation. Eventually humans got involved and actively crossbred plants with desired traits hoping to raise livestock and grow crops that were healthier, more efficient, and in some ways better than what came before. The downside of all this was that all of these advances took a lot of trial and error. A great deal of time and effort was spent crossbreeding and waiting for the result to mature to see if the experiment was a success.

10 genetically engineered crops available today:

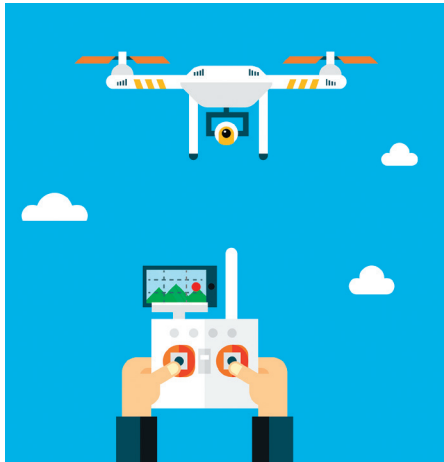
alfalfa	apples
canola	corn (field and sweet)
cotton	papaya
potatoes	soybeans
squash	sugar beets

Today, genetically engineered plants contain genes from other plants to make them grow better and safer, allow for more control, and less trial and error. Simply stated, genetic engineering takes a naturally occurring event and speeds it up. Genetically modified crops require fewer inputs (like water or pesticides), are more disease resistant, and allow farmers to utilize no-till farming methods that conserve soil health.

Additionally, it is important to note that farmers are not the only ones who benefit from genetically engineered crops! Do you enjoy eating fresh fruit? Genetic engineering was used to save the Hawaiian Rainbow papaya from the deadly ringspot virus which threatened to wipe out the crop, and the industry.

From the Farm to the Cloud

Today's farmers have become more efficient by being more innovative. Farm equipment, recordkeeping, moisture monitoring and waste management have all advanced to new levels of innovation in the last couple of decades. Tractors can come equipped with GPS units, allowing the farmer to know his or her exact location in a field down to a meter's accuracy. GPS equipped tractors make every task a farmer

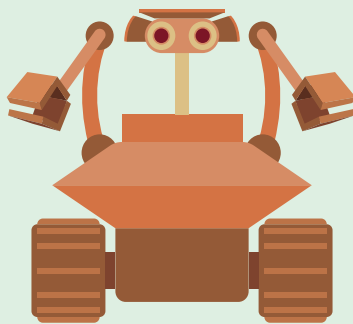


completes in his or her field more efficient, from keeping the tractor wheels between the rows, to preventing overlap in planting and spraying, to producing better yields when harvesting.

Have you grown a garden or watched someone tend to one? A gardener devotes attention and detail to his or her plot—checking for pests, pulling weeds, watering, etc.—working to ensure the plants survive to produce fruits or vegetables come harvest. It would be impossible for a farmer to dedicate that attention to rows and rows of crops. Thankfully, modern technology steps in again! Using cameras in airplanes, drones, and satellites, farmers today can survey every acre of their land in a fraction of the time it would take to walk the fields. Airplane and drone pictures allow for frequent, close-up views of crops, while satellite pictures allow for analysis of large areas of

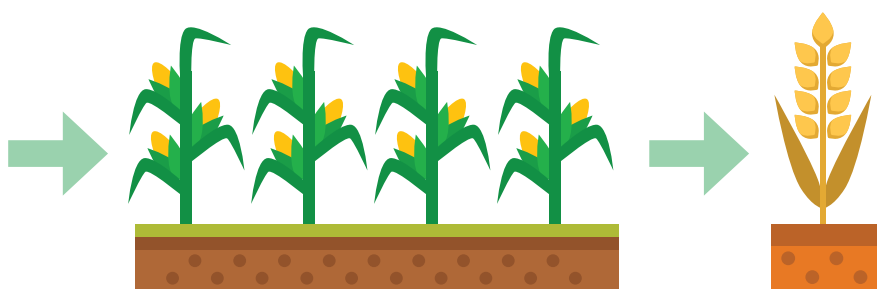
land. Collecting all of that data also lets farmers make comparisons across decades. These images are fed to computers to analyze the fields for weeds, crop cover, moisture content, and general field health. The sooner a problem is detected, the easier it can be fixed. Airplanes, drones, and satellites can detect problems before they are visible to the naked eye.

Let's Talk About Robots

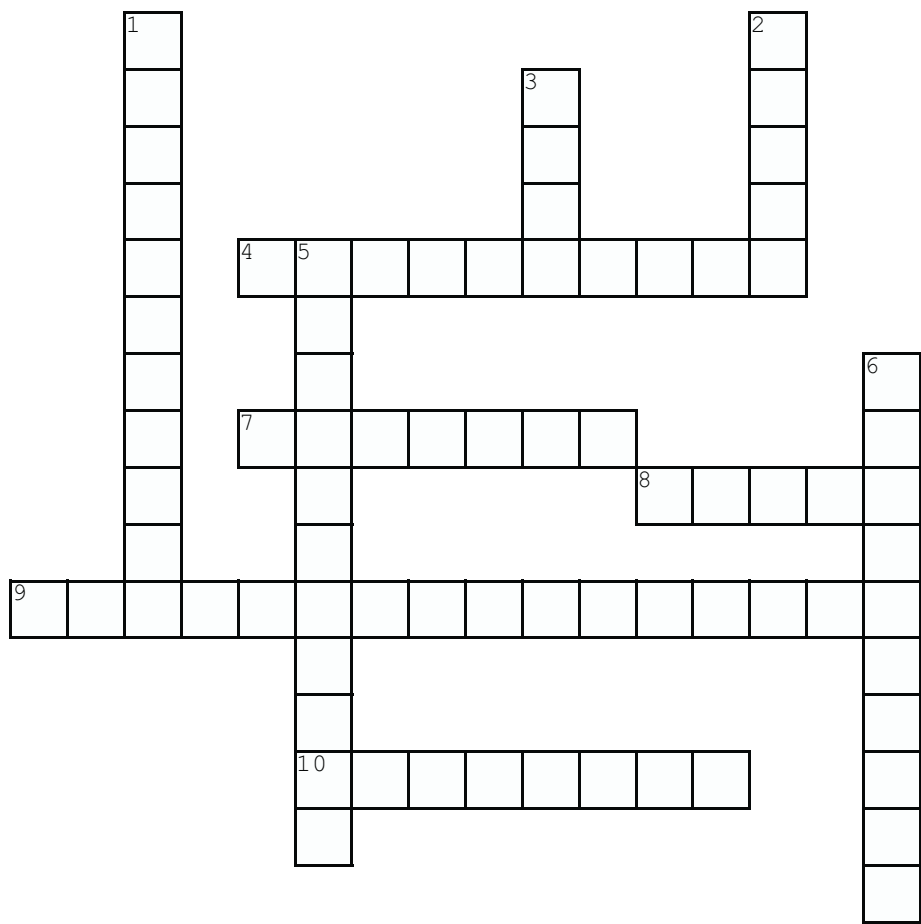


We can't talk about high-tech farms of the future without talking about robots. Researchers from the United States and around the world are developing farm equipment that works by itself to improve crop quality. Exciting developments include robots on wheels that travel through rows of crops to identify and kill weeds, apply fertilizer, or check the health and needs of individual plants. Imagine being able to kill weeds one at a time with small doses of fertilizer (or lasers!) instead of spraying entire fields. Fifty years ago farmers joked about self-driving tractors, but now many farmers are happily embracing this technology.

*Technology has allowed farms to provide water, herbicides and fertilizers to individual plants.
We've gone from spraying whole fields to individual plants.*



Precision Farming



ACROSS

- 4. Farmers develop more efficient ways of growing crops and raising livestock by being _____ .
- 7. Scientists cross-breed plants and animals using _____ engineering.
- 8. The single most important resource.
- 9. The use of new technology to make growing crops more efficient.
- 10. Farmers must balance their farms like an _____ .

DOWN

- 1. To preserve our land and resources for future generations, farmers are implementing _____ farming practices.
- 2. Small, remote-controlled flying machine that farmers use to take pictures of their land.
- 3. Information collected and used to make decisions on the farm.
- 5. Percent of farms that are family owned and operated.
- 6. Farmers water their crops using _____ systems.

Discussion Questions/Activities

- 1. How do precision farming methods conserve water and other resources? Why is this important?
- 2. Why has genetic modification been important throughout human history and why will it be important in the future?
- 3. NASA is an unexpected proponent of sustainable farming. What other government or private organizations could also help the future of farming? How do you think they could help?

FARMING: HIGH-TECH INDUSTRY?

If asked to name some high-tech jobs, what would you say? High-tech jobs include computer programmers, architects, engineers, and even airline pilots, but what about farmers? If you don't consider farming to be a high-tech job, it's time to think again. Farmers and ranchers today use technology in numerous ways to make their operations more sustainable (and profitable!) and to maximize all available resources. Farming is one of the most high-tech jobs out there!

GPS. The Global Positioning System is a system of satellites which allow us to map locations on Earth with incredible accuracy. GPS allows farmers to be precise when planning and mapping fields, as well as when planting, irrigating, spraying and applying nutrients.

Satellite Imaging. Along with GPS, satellites provide information on the condition of crops in a particular field and help farmers track changes over time.

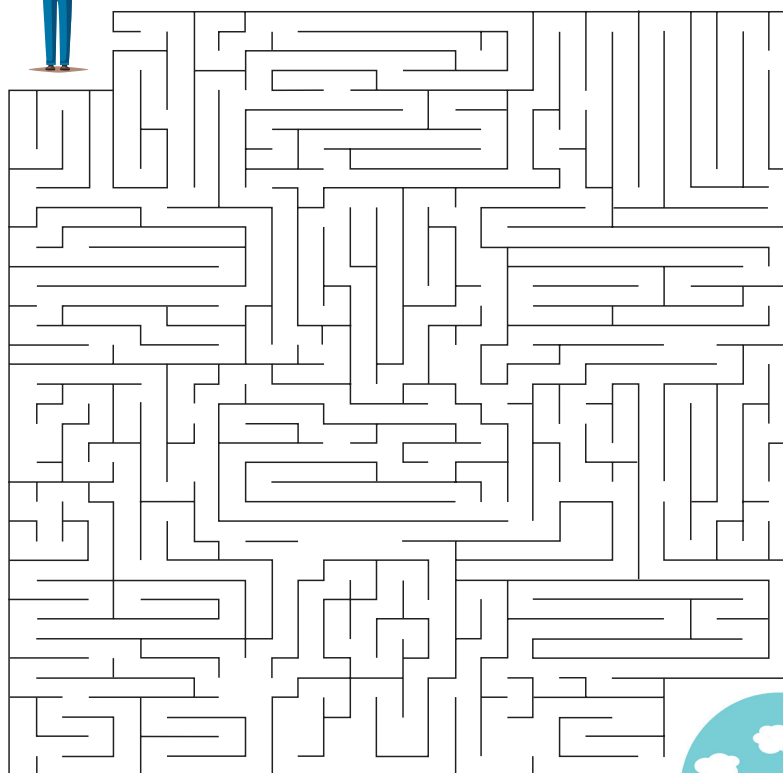
Drones. Farmers can fly drones over fields to quickly check crop yields, the location of cattle, and the prevalence of insects and pests damaging crops.

Soil Sensors. Soil sensors are deployed across the farm to measure water and nutrient content in the ground allowing the farmer to accurately identify the “needs” of the crops in individualized locations.

Smartphones. Not just for social media and games, smartphones can also be used to check crop prices and incoming weather, track crop yields, and control machinery such as irrigation equipment.



David needs to look at his soybean plants to see if they are healthy and growing. While he could fly his drone above the crops, find the path he could take to walk from one end of his field to the other.



Discussion Questions/Activities

1. What are some of the ways that you use technology at home, at school, and on the farm? How has technology changed from when your parents were your age?
2. What are the benefits of using up-to-date technology on the farm? Are there any disadvantages?

SUSTAINABLE ANIMAL PRACTICES

Sustainable farms aren't all about row crops, fruits and vegetables. Farms that raise cattle and other livestock also have the responsibility and the means to raise their animals in sustainable and humane ways. A combination of new technologies and old methods show us the way.

1. As seen before, genetic selection has successfully been used in crops to develop new varieties of seeds that perform optimally in their environment. A similar concept has also been utilized in the livestock industry. For example, in the past a cattle rancher had to rely on visual appraisal of a bull to decide if he would fit well within his herd. While this remains valuable in cattle selection, ranchers can now use a genetic prediction tool to more accurately identify if the bull will perform well within his herd. With the help of modern technology, farmers and ranchers can select for cattle that are stronger, healthier, and better adapted for their home environment.
2. GPS and sensor technologies are used on some farms to track the activity level and health of individual animals. These sensors allow for early detection of problems, which allows for intervention before it is too late. Some technologies have been referred to as a FitBit for cows because of their tracking capabilities! Sensors can also tell farmers the best timing for breeding.
3. Livestock producers also use rotational grazing to preserve natural resources. By moving livestock from place to place on the farm, only one portion of the pasture is grazed at one time, while other areas can rejuvenate. This practice reduces soil erosion, improves soil health, and allows for manure to be used as a fertilizer for the soil.



Discussion Questions/Activities

1. Why is it important to treat animals like living creatures instead of as machines?

SUSTAINABILITY AT HOME AND SCHOOL

As you have seen, we can do great things to increase a farm's success through sustainable and precision farming methods! Using sustainable and precision farming techniques can help increase crop yields, minimize environmental impact, and maximize profits. But what about your home and school? How can you help your family, classmates, and teachers conserve resources and make your home and school the best places they can be? Here are four ways you can help:

Water. As seen before, water is possibly the most valuable resource for farmers, but also a resource easy to waste or pollute. At home, simple steps like fixing leaky faucets, turning off the water while brushing your teeth, and taking shorter showers can lead to huge water savings.

Energy. We don't often think about it, but we use a lot of energy in our homes and schools. What are some easy ways to use less energy? Checking windows and doors for leaks, turning off TVs and computers when not using them, and keeping the house a couple degrees cooler in the winter and warmer in the summer all lead to big energy savings.

Recycle. By recycling items such as paper, plastic, and aluminum we not only reuse them instead of filling up landfills, we also save energy from producing new packages. Many places around the country will recycle these items and much more.

Be a Leader. Most importantly, you need to lead the way! If you want your family, classmates, and teachers to join your conservation efforts, ask them to do as you say AND as you do! People who lead through words and example are the most effective leaders. Show your family and school what to do and they will follow.

Quick Facts

- The United States has **5%** of the world's population but uses **26%** of the world's energy.
- Recycling **one** aluminum can saves enough energy to power your computer for **3 hours**.
- A single dripping faucet could waste **165 gallons** of water every month.
- Aluminum cans take **90 years** to biodegrade, plastic bottles can take **700 years**, and a glass bottle can take **1 million years**!

Sustainability Word Search and Find

N	E	O	Q	M	M	L	E	R	E	D	A	E	L	T
Q	V	R	C	P	U	N	D	I	C	K	E	F	M	U
O	M	R	X	C	N	L	A	F	O	L	L	I	Z	R
H	W	Q	I	Q	I	S	R	W	N	H	C	H	P	R
W	U	O	T	T	M	S	G	J	S	C	Y	E	R	S
A	O	U	K	M	U	A	E	W	E	M	C	H	D	M
T	W	N	V	A	L	L	D	C	R	V	E	K	W	Q
E	C	S	E	Y	A	G	O	M	V	R	R	Q	T	F
R	W	N	H	M	K	G	I	P	E	W	C	V	R	L
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C	Q	Y	H	U	I	L	A	J	Q	Y	Y	E	C	E
Y	K	T	O	V	H	P	L	M	E	X	F	T	Y	J
R	L	Z	C	J	R	Q	M	I	A	W	C	L	J	E
R	U	B	H	N	L	F	E	W	O	L	N	P	B	S
N	E	N	E	R	G	Y	L	E	X	N	E	K	C	U

RECYCLE
ALUMINUM
CONSERVE
GLASS
ONE MILLION
LEADER
WATER
ENERGY

Discussion Questions/Activities

1. Do you know how sustainable your home is? Ask your family to help you check windows for leaks, fix leaky faucets, and change to energy-efficient light bulbs.
2. If your school doesn't have one, start a recycling program. Your teachers and principal will appreciate your leadership. Be sure to include other students in your efforts!
3. What other steps can you take at home and school? Be creative to find ways to reuse or recycle old materials.
4. Why do you think some people are reluctant to conserve resources at home? How can you convince them to make these small but important changes?

No-Till Farming—Sustainability in Action!



Imagine a farm in planting season. A farmer rides a big piece of farm machinery and churns over the soil in the entire field before planting crops in neat rows. With all the soil turned over, or tilled, the field is now in the best shape for planting, right? Well, maybe not.

No-till farming, a soil conservation method that is becoming rather common in the crop industry, seeks to improve the agricultural industry by minimizing the soil that is disturbed for planting.

Traditional tilling methods disturb large amounts of soil, a practice that has been shown to contribute to soil erosion, fewer nutrients in the soil, and the release of more carbon into the atmosphere.

On the other hand, no-till farming digs into the soil only where it is needed to plant the seeds, while leaving the rest of the soil in the field undisturbed. This practice keeps nutrients in the ground, minimizes erosion and carbon emissions, reduces fuel and labor costs and aids in soil moisture conservation. Talk about sustainable farming!



Remember, the food grown and raised by farmers is the same food we buy in the grocery store. One of the greatest things about American agriculture is that we have so many choices at the supermarket!

ENVIRONMENTAL IMPACT

While sustainable and precision farming save time and money in the production of healthy and affordable food, all of that is wasted if the land and water cannot be passed on to the next generation. Sustainable farming strives to make the best use of the resources we have, while conserving or improving them for our children and grandchildren. There are many other ways that farms can be sustainable.

Crop Rotation. A practice that's been around for thousands of years, farmers rotate which crops are planted in certain fields over several years. Different crops add and deplete nutrients from the soil. By alternating what is planted, the soil can recharge itself and continuously grow healthy crops.

Cover Crops. Most farms only have crops in their fields part of the year. The rest of year, often in winter, the fields are empty. Cover crops are planted during off-seasons to prevent soil erosion, keep nutrients close to the surface of the soil, and improve overall soil health.

Contour Strips. These small, grassy hills between rows of crops limit soil erosion, improve water quality, and control irrigation. Contour strips minimize water loss and allow for more water to be absorbed into the soil.

Grain Bin Location. Believe it or not, where a grain bin is located for storing crops before market can have huge effects on the amount of fuel a farm uses. By placing a grain silo near a roadway, a farmer can conserve the amount of fuel he or she uses to unload or transport the grain to market.

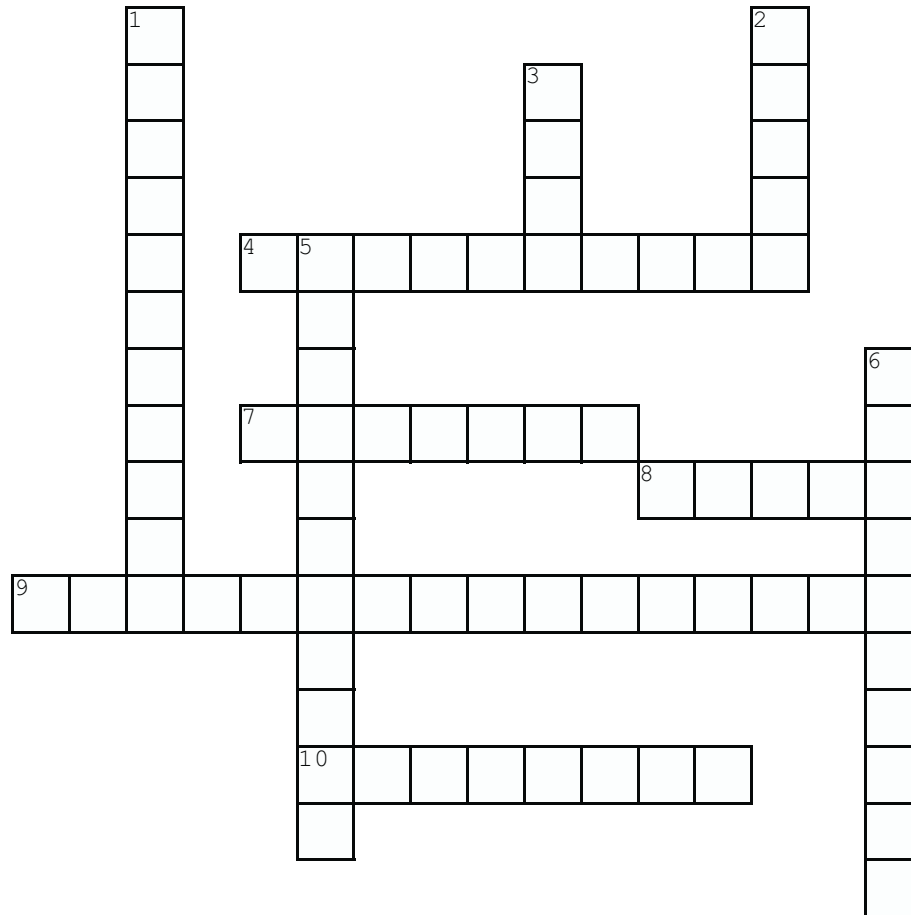
Certifications. Various farming organizations and even companies that buy products from farms are creating certification systems for farms that are deemed to be "sustainable." These certifications encourage farmers to invest in sustainable farming methods; some companies even prefer to buy from only sustainable farms or to pay more for goods from those that are certified. That's financial incentive!

Solar/Wind Energy. Efficiently using and conserving energy on farms is a big piece of sustainability. Some studies say that U.S. agriculture has doubled its average energy efficiency over the last 25 years, but there are more opportunities ahead. Farmers can now use solar panels, windmills and/or wind turbines to generate electricity in a more efficient manner.

It takes time, money, and effort to become sustainable, and those efforts don't happen overnight. It is best to think of sustainable farming as a journey, rather than a destination. We may never get 100% of the way there and the target may change, but if we continually move in the right direction, we'll do what is best for our planet and our people, both now and in the future.

ANSWERS

Precision Farming Crossword



ACROSS

4. Farmers develop more efficient ways of growing crops and raising livestock by being _____.
Answer: innovative
7. Scientists cross-breed plants and animals using _____ engineering. *Answer: genetic*
8. The single most important resource.
Answer: water
9. The use of new technology to make growing crops more efficient. *Answer: precision farming*
10. Farmers must balance their farms like an _____.
Answer: equation

DOWN

1. To preserve our land and resources for future generations, farmers are implementing _____ farming practices.
Answer: sustainable
2. Small, remote-controlled flying machine that farmers use to take pictures of their land. *Answer: drone*
3. Information collected and used to make decisions on the farm.
Answer: data
5. Percent of farms that are family owned and operated.
Answer: ninety seven
6. Farmers water their crops using _____ systems.
Answer: irrigation