The image features a minimalist design with several overlapping circles in various shades of light blue. A thin vertical line runs down the right side of the page. The text 'Sustainable Agriculture' is positioned on the left side, underlined.

***Sustainable Agriculture***

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# Sustainable Agriculture

## Introduction

We are all eaters; we all require food. The way that we choose to meet our dietary needs will affect the future health of the planet. Agriculture is necessary to support Earth's human population; we now need to find and implement ways to create healthy and adequate food while protecting and preserving the natural resources that agricultural production depends on.

When we look at both the recent and distant agricultural past, we can find many examples of successes and failures that can guide our decision-making processes as both producers and consumers of food today. We can use this information to improve the sustainability of the food system, starting with agriculture.

## What is sustainable agriculture?

It is working towards a balance between food production activities and protection of the natural resources that agriculture depends on. In addition, it is the food system's ability to generate adequate income to compensate farmers for their time, labour, and risk while they produce agricultural products that are affordable enough for consumers to purchase.

Nutritional needs should also be considered and included when making decisions about sustainable food production (consider caloric, protein, and micronutrient needs).

## Three pillars of sustainability

There are three pillars of sustainability: economic, social, and environmental. All three must be considered and a balance among them established when creating and maintaining sustainable food systems.

- **Economic sustainability:** The ability to produce more food with the same inputs or to produce the same amount of food with fewer inputs.
- **Social sustainability:** Sustainable systems must provide desirable working conditions/lifestyles for those who are involved with agricultural production, and the food that is produced must be affordable for consumers.
- **Environmental sustainability:** Production practices must preserve and protect the natural ecosystem that farming depends on.

An example of these three pillars of sustainability in action can be found in Norman Borlaug's "Green Revolution." In the 1950s and 1960s, Borlaug bred new rust-resistant dwarf wheat varieties that, when fertilized with nitrogen, increased grain yield worldwide by 150% between the years 1950 and 1992. The new dwarf wheat varieties put more energy into large seeds than tall straw, which created larger yields per acre. Yields were also improved because the new varieties were less susceptible to the wheat disease known as rust. However, Borlaug's system also required heavy use of nitrogen fertilizer and fossil fuels, and a high degree of mono-cropping.

Looking back we can now see that the Green Revolution was not as *economically sustainable* as once believed. While the system was able to realize a substantial increase in terms of yield per acre, it required larger amounts of purchased inputs such as nitrogen fertilizer and fossil fuels. The gains in yield were made by converting natural resources (like fossil fuels) into fertilizers to produce food.

This in turn influenced the *social sustainability* of the Green Revolution. Because farmers had to purchase more inputs (mainly during the early crop planting and establishment phase), their risk grew. Higher spring costs often meant that margins for profit were smaller during good years, and in years of crop failure the loss was much larger than before.

Finally, the *environmental sustainability* of farming was affected by the Green Revolution. The reliance on nitrogen fertilizer increased the amount of fossil fuels used to create edible food, and this altered the energy-use ratio negatively. The preference for mono-cropping in this system has also reduced on-farm biodiversity.

In conclusion, sustainability was not a driving concern at the time of the Green Revolution; instead, the goal was simply to *increase agricultural production*. From this example, we can see that increases in agricultural productivity often come at the expense of the people involved with production and the natural ecosystem. (This is an example of achieving food security at the expense of agricultural sustainability.)

### How the Green Revolution became unsustainable

Future increases in yield are not sustainable if they cause any of the following negative impacts:

- Degradation of natural resources
- Loss of biodiversity
- Spread of pests and diseases across natural and political borders that can affect agricultural production

It is important that future innovations consider the three pillars of sustainability, rather than just focus on increasing agricultural production levels.

Today, we can see that agriculture has come up against some *hard limits*, like a finite land base for agricultural production (agricultural land in both the new and old worlds has been maximized). This means that previous ways to increase global food production (like cultivating new/additional acres of land) are no longer available as choices: we need to find new ways to produce food that respect these hard limits.

The large global population is extremely dependent on modern agriculture to meet its food needs, and the ways in which those needs are met will be vital to the long-term health and success of our global population. Agriculture can help to both mitigate and adapt to climate change, but it is also a contributor to climate change.

The sustainability of global agricultural production has changed. The gradual intensification of agricultural production to meet the food needs of a growing population has decreased agriculture's sustainability over time. Perhaps working with producers to adopt the first of many *small steps* towards improving the sustainability of agricultural production will help to reverse this trend.

## Changes in Agricultural Systems and the FAO

Food and agricultural systems are currently undergoing large-scale changes and are becoming increasingly

- globalized
- concentrated
- industrialized
- science-intensive

The above changes in agricultural systems can

- create barriers for small and medium-sized farms to access sustainable knowledge and tools
- make it difficult for both men and women to access sustainable knowledge and tools equally
- result in the growing trend towards proprietary biotechnology in agriculture, where its use comes with protection instruments that prevent dissemination to farmers who would benefit

Currently, only 2% of the people living in North America are directly involved in food production, with many more involved in the food transport and processing sectors. Agriculture makes up 8% of Canada's GDP (this number is higher in Manitoba).

The FAO (Food and Agriculture Organization) is a specialized agency within the United Nations that is focused on all aspects of food and agriculture, including food production, sustainability, food security, and nutrition.

The FAO's vision is of a "world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner." (da Silva, 2017)

The main goals of the FAO include

- ending poverty, hunger, and malnutrition
- enabling sustainable development in agriculture, fisheries, and forestry
- combatting and adapting to climate change

To become more sustainable, the FAO advises that agriculture must

- meet environmental challenges
- adopt greener practices
- ensure social and political sustainability within production systems

The FAO believes that agriculture will achieve these goals by

- adopting innovations that are able to increase productivity and efficiency while using resources sustainably
- making better use of energy to create food

# Sustainable Agriculture

## The Characteristics of Sustainability

Agricultural sustainability could improve by

- decreasing greenhouse gas emissions
- decreasing water use and water pollution
- decreasing soil erosion and soil degradation
- increasing the health of soils
- decreasing the use of inputs (especially finite resources like phosphorus)
- decreasing the heavy reliance on fossil fuels (fossil fuels are used to create nitrogen fertilizer, run machinery, transport food products long distances, etc.)
- improving the resiliency of crops to adapt to changing climate conditions
- increasing agricultural efficiency by decreasing the amount of energy used for each calorie produced.
- decreasing the reliance on monocultures in large-scale agriculture systems/ increasing biodiversity in all agricultural systems
- increasing the efficiency and profitability of farming (decreasing food lost during production; finding accessible markets and establishing fair prices)
- increasing conservation efforts for natural areas within and adjacent to agricultural areas (eliminating deforestation to create new agriculture land; protecting and preserving natural wetlands and grasslands; planting and maintaining shelter belts, etc.)
- practising various forms of soil conservation and restoration
- improving the efficiency of fertilizer use and reducing its environmental impact by practising the 4Rs
- employing innovative sustainable cropping systems that increase yields while improving soil health
- employing innovative livestock systems focused on maximizing resource efficiency while decreasing negative environmental impact
- making better use of waste products (both human and animal) and recycling the nutrients needed for food production (e.g., using manure as crop fertilizer)
- adopting more sustainable production systems
- protecting and preserving ecosystem services

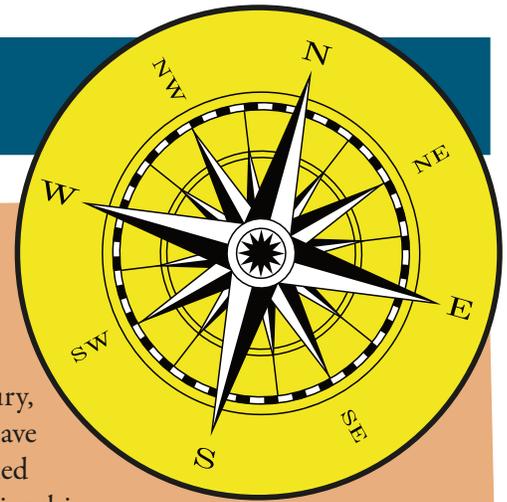
Sustainable systems are characterized by the following traits:

- Excellent resource-use efficiency
- Promotion of diversification
- Consideration for climate change adaption and mitigation

## **Incorporating technology to improve efficiencies in production**

Agricultural production can be made more efficient by

- utilizing GPS technology with precision agriculture machinery
- using new data collection tools to make evidence-based decisions (e.g., drones provide great visual information; combines provide extensive data to help make production decisions; scales and ear tags provide detailed feeding and health information for selecting efficient animals, etc.)
- finding efficiencies through advances in genetic science, particularly in breeding plants and livestock where fewer inputs are required to achieve the same yields
- conserving wetlands and grasslands
- planting and maintaining shelter belts
- avoiding production in marginal and vulnerable areas (e.g., riparian areas, steeply sloped areas, etc.)



## Exploring the Issues

- Agriculture has been a key player in the global pattern of continual yet unsustainable growth. The more predictable a food supply is, the bigger a population it can support. This sets up the following cycle: an increase in agriculture yields causes a decrease in the cost of food, which causes an increase in population size, which then requires an additional increase in food production. The cycle continues, but because Earth is a finite size, continued human population growth is not sustainable in the long term.
- Population increases and intensified land use for agricultural production have often been achieved at the expense of the surrounding natural ecosystem. This scene has been replayed many times globally since agriculture began, and many former civilizations have ended (in part) because of unsustainable agricultural production practices, including the Sumerians at Ur, Easter Island (Rapa Nui), and Greenland's Vikings.
- It is important to remember that not all civilizations ended with the intensification of agricultural production. Some civilizations successfully farmed the same area and lands for thousands of years while maintaining/preserving the natural resources. These include China, Egypt, and parts of Northern Europe. By looking at these practices, both in the past and how they have been adapted for present use, we can learn about various strategies to improve agricultural sustainability.
- Over the past century, humans have transformed their relationship with the natural world, greatly increasing their use of Earth's natural resources. This has led to environmental degradation over time, and some of that degradation will not be reversible.
- The global trend is *towards increasing scarcities of our natural agricultural resources*, including land, water, forests, fish, and biodiversity. With the intensification of human activities, there have been increasing pressures on the world's natural agricultural resources. This is starting to cause negative changes in Earth's ecological functioning. The increasing global population will require new strategies to maintain/increase food production while taking steps to protect and preserve the natural environment.
- Global food demand is rising and changing, with increased demand for livestock products, fish, fruits, vegetables, oils, and sugar. Despite these trends towards increased global consumption, there are also a significant number of people who are undernourished or who have micronutrient deficiencies. All people need access to food at reasonable prices, and this must be a consideration of agricultural sustainability; food needs to be affordable, especially for the poorest and most vulnerable populations.

## Sustainable Agriculture

- Global agricultural production has increased threefold from 1960–2015 due to increases in production from Green Revolution technologies, including a heavy reliance on fossil fuels, water, and other agricultural inputs, and expansion of new agricultural land. These practices have decreased the sustainability of agricultural production.
- Global yield increases have now slowed in terms of bushels per acre or kilos per hectare. Future increases in yield are predicted to be due to the development of adapted and improved varieties of crops and getting these new varieties to farmers who can benefit. This raises the social issue of the trend towards proprietary biotechnology within agriculture, as these protection instruments prevent advances in food production from being shared by all. Privatization of knowledge and tools that can improve the sustainability of agriculture means that these are not available to all farmers
- Modern agriculture is *more extensive* (advances in technology allow for fewer people to cultivate more acres of farmland) and *intensive* (high use of inputs) than historic agriculture was. As a result, agriculture's negative impact on the natural environment is now visible in a variety of ways.
- Currently there is competition over natural resources for both food and non-food products (e.g., competition over forests, which act both as the cleaners and keepers of water for agriculture, and as providers of raw goods in the form of wood for loggers; competition over land for various uses including agriculture, city expansion, infrastructure, mining, etc.).
- Disparity exists among global farmers and international consumers. It is important that the interests of the poorest farmers and poorest consumers are considered. Everyone needs to be able to create, sell, and buy food at reasonable prices for the system to be truly sustainable.
- The world is currently able to produce adequate food to satisfy the needs of the global population, but waste, cost, and transportation prevent food from being equally distributed to all.
- Reducing food loss and waste would lessen the need for increases in agricultural production, as 40% of the food produced does not end up being consumed.

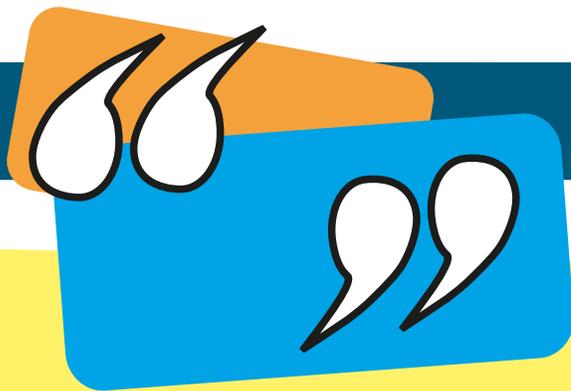


### Essential Questions

- What is the proper use of land? In the past, hunter-gatherer food systems have been viewed as inferior to agriculture. This reasoning was used as a claim for acquiring Indigenous land for agricultural purposes in Canada. Because it was perceived that Indigenous occupants were not making full use of their treaty land, amendments to the *Indian Act* in 1918 gave Canada's Department of Indian Affairs the power to lease or give band land to non-Indigenous people for the purpose of cultivation.
  - How can farmers increase agricultural production and protect the natural resources they are dependent on while improving sustainability? (Note: Agriculture produces more than just food for people; it also produces fuel, fibre, and feed.)
  - What is the role of the urban consumer in improving agricultural sustainability? Urban issues include the following:
    - Informed decision making in food purchases
    - Excessive food waste
    - Proper recycling of nutrients found in agricultural products (how to recycle nutrients back into the agriculture system)
  - What are the connections among agricultural sustainability, food safety, and food security? (Understand how these ideas are interrelated, yet completely different.)
  - What is done in the short term to address food security must not undermine the long-term objectives of food production and natural resource sustainability.
  - Countries that engage in food trade must balance their needs for food security against other nations' needs for security and sustainability.
  - Is access to food and freedom from hunger a basic human right? What would food systems look like if this right were extended to all people? What would that mean for producers and consumers? What would have to change in our current food system?
- How can the sustainability of various agriculture production practices and systems be evaluated? What criteria should be included? What scale should be used? How much of the food system should be evaluated? (Look at the criteria developed by McDonald's for its Sustainable Beef Verification Program and compare this with the 10 challenge areas created by the FAO for improving agricultural sustainability.)

### Did You Know?

- Agriculture is a basic human endeavour. It developed independently on every continent with human habitation (except Australia).
  - By 5000 years ago, the majority of people living on Earth had made the transition from eating mostly wild foods to eating mainly domesticated ones. Today there are very few people that rely on hunting and/or gathering for the majority of their food; the world now relies on agricultural production for almost all of its food needs.
  - The New World staple crops of maize and potatoes produced twice the calories per acre when compared with the Old World staples of wheat and barley, while the Old World cereal crops were an ideal match for the growing conditions of the South American Pampas and the North American prairies. Although agriculture developed independently at numerous sites worldwide, it has now become one big system that covers much of the planet.
  - Agricultural practices may not achieve a completely neutral environmental impact. Despite improvements in sustainability and increased protection of the natural resources involved, agriculture may still have a negative impact on the health of the planet (but this doesn't mean that humans will stop producing food—the first priority for civilizations).
  - There are a wide range of farms worked, commodities created, and agricultural production practices employed in Manitoba and globally, and each will have a different environmental footprint. The sustainability of a farm's production practices depend partially on the regenerative power of the land/ecosystem it is situated on/in. Because of this, each situation must be treated individually with regards to sustainability (there is no one right solution for improving sustainability for all farms).
  - Both McDonald's and the UN's FAO have been working on developing criteria to assess the sustainability of agricultural production.
  - Agroecology is the science of applying ecological concepts and principles to the design and management of sustainable food systems. It is seen by many as the key to future agricultural sustainability because it addresses issues such as poverty, climate change, and food insecurity. (FAO, Nov 2016)
- Agroecology uses ecological theory to design individualized food systems that address the following:
- agriculture community ecology (soils, plants, animals, markets)
  - nutritional ecology
  - human ecology



### Thought-Provoking Quotations

“Farming achieved quantity at the expense of quality: more food and more people, but seldom better nourishment or better lives.”

– Ronald Wright (47)

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“There is no more essential commodity than food. Without food, people perish, social and political organizations disintegrate, and civilizations collapse.”

– Norman Borlaug (Hesser)

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“Civilizations have developed many techniques for making the earth produce more food—some sustainable, others not. The lesson I have read in the past is this: that the health of the land and water—and of the woods, which are the keepers of the water—can be the only lasting basis for any civilization’s survival and success.”

– Ronald Wright (105)

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“The natural resource base and ecosystem services are the foundation of all food and agriculture systems, and their protection is a guiding principle in their use.”

– José Graziano da Silva (FAO, 2013)

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“Land has always been a defining element of Aboriginal culture. Land contains the languages, the stories, and the histories of a people. It provides water air, shelter, and food. Land participates in the ceremonies and the songs. And land is home.... For non-natives, land is primarily a commodity, something that has value for what you can take from it, or what you can get for it.”

– Thomas King

(Note: King later clarified that all people can feel deep attachment to the land, and that by *non-natives* he meant “North America’s societal attitude towards land”.)

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“Much progress has been made in reducing hunger and poverty and improving food security and nutrition. Gains in productivity and technological advances have contributed to more efficient resource use and improved food safety. But major concerns persist. Some 795 million people still suffer from hunger, and more than two billion from micronutrient deficiencies or forms of over nourishment. In addition, global food security could be in jeopardy, due to mounting pressures on natural resources and to climate change, both of which threaten the sustainability of food systems at large. Planetary boundaries may well be surpassed, if current trends continue.”

– José Graziano da Silva (FAO, 2017, vii)

“High-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. Needed are innovative systems that protect and enhance the natural resource base, while increasing productivity. Needed is a transformative process towards ‘holistic’ approaches, such as agroecology, agro-forestry, climate-smart agriculture and conservation agriculture, which also build upon indigenous and traditional knowledge. Technological improvements, along with drastic cuts in economy-wide and agricultural fossil fuel use, would help address climate change and the intensification of natural hazards, which affect all ecosystems and every aspect of human life.”

– Food and Agriculture Organization of the United Nations (FAO, 2017, xi)

“The average Canadian household saves more than \$4,000 on their annual food bill because farmers use plant science technologies to help protect their crops from insects, weeds and diseases.”

– CropLife Canada, 2017

“Canada will become the trusted global leader in safe, nutritious, and sustainable food for the 21st century.”

– The Advisory Council on Economic Growth



## Making a Difference

*How do consumers have an impact on production practices in agriculture?*

“Eating is an agricultural act.”

– Wendell Berry

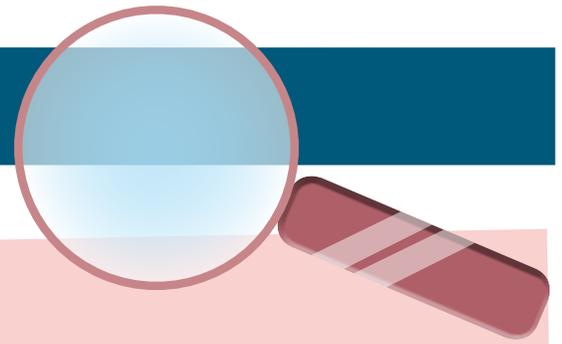
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Manitoba egg producers respond to consumer desires and values with a variety of whole egg products. Look at the shelves of eggs in any supermarket/grocery store and you will notice there are six main choices (beyond size and shell colour) that are available to consumers. The first four describe differences in the hens’ housing. The first five have the same nutritional profiles.

- **“Classic” (i.e., traditional cage-laid eggs):** This system, which replaced open cage-free systems to improve hen welfare and farmer care, is the least expensive option and the production system that is most commonly used on Manitoba farms. It involves small flocks of hens living together in plain cages.
- **Enriched systems/nest-laid eggs:** This system features larger cages (more room per hen) and includes features to encourage natural chicken behaviour (e.g., a perch system, scratch pads, a private area for laying eggs, etc.).
- **Free-range systems:** Free-range systems have no cages. Large numbers of hens live together in indoor barns, their food and water is available freely, and there are nest boxes along the perimeter for hens to lay their eggs. Chickens have access to the outdoors when weather conditions allow. There are few free-range egg production systems in Manitoba due to our cold winters.
- **Organic:** In this system, the hens that lay the eggs were fed organic feed.
- **Omega-3 eggs:** Omega-3 eggs are the only eggs with any nutritional difference, as they have been fortified with two different omega-3 fatty acids: DHA (docosahexaenoic acid) and ALA (alpha linolenic acid). These acids have been linked with the proper development and maintenance of brain cells. This is accomplished by feeding the hens flaxseed.

The Egg Farmers of Manitoba organization watches egg sales closely to determine consumer trends, and it works with the egg producers of the province to meet consumer needs. If one of the previously listed egg types begins to become more popular with consumers, farmers are encouraged to adopt the new production style. In this way, consumers have a direct influence on the production practices of Manitoba egg farmers when they choose a type of egg at the supermarket.

This choice at the food purchasing level can also extend into other production systems that have a greater impact on sustainability. (Look at the differences in sustainability of two different production systems: beef from feed lots versus grass-fed beef).



## Glossary

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**Agricultural products:**

The wide range of resources produced through agriculture, especially crops and livestock.

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**Agricultural production:**

The process of growing crops and livestock.

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**Crops:**

A cultivated plant that is grown as food, such as wheat, fruit, or vegetables.

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**Cropping:**

The process of harvesting crops, as part of agricultural production.

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**Cultivate:**

Growing plants or animals for food, as part of agricultural production.

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**Domesticated:**

A plant or animal that is cultivated for food, as part of agricultural production.

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**Economies of scale:**

Cost savings as a result of increased production.

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**Extensive agriculture:**

Agricultural production that requires less labour, fertilizer, and capital than typical systems of agricultural production.

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**Intensive agriculture:**

Agricultural production that requires more labour, fertilizer, and capital than typical systems of agricultural production.

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**Food safety:**

Methods to produce, handle, prepare, and store food in ways that prevent food-borne illness.

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**Food security:**

Having consistent and reliable access to adequate, affordable, and nutritious food.

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**Livestock:**

Cultivated animals used in agricultural production.

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**Lodging:**

Damage to the stems of grain crops, making them difficult to harvest. It is often caused by a combination of a weak crop and conditions such as rain, wind, hail, topography, and poor soil.

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**Organic:**

Agricultural products produced without the use of chemical fertilizers, growth stimulants, antibiotics, or pesticides.

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**Production practices:**

The systems used to grow agricultural products.

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**Profit:**

The money left over from the sale of products after all expenses from their production have been subtracted.

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**Sustainability:**

Meeting our own needs without compromising the ability of future generations to meet their own needs.



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**Wild:**

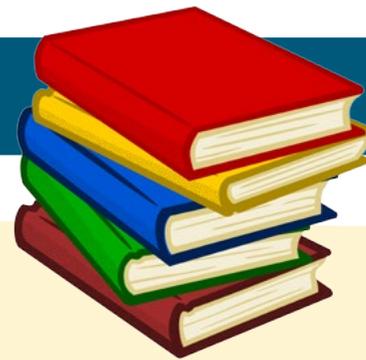
Living and growing in a natural environment (i.e., not domesticated).

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**Yield:**

To produce or provide; the result of production.

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## Resources

### Online Resources

Food and Agriculture Organization of the United Nations (FAO). *The Future of Food and Agriculture: Trends and Challenges*. New York, NY: FAO, 2017. Available online at <http://www.fao.org/3/a-i6583e.pdf>.

*“How can we achieve FAO’s original vision of a world free from hunger and malnutrition? The report sheds some light on the nature of the challenges that agriculture and food systems are facing now and throughout the 21st century, and provides some insights as to what is at stake and what needs to be done. What emerges is that ‘business as usual’ is no longer an option but calls for major transformations in agricultural systems, in rural economies and in how we manage our natural resources.”*

Manitoba Agriculture. *Agricultural Climate of Manitoba*.  
<https://www.gov.mb.ca/agriculture/weather/agricultural-climate-of-mb.html> (date accessed—2017-12-05)

*“This reference tool is for agricultural producers and agribusiness. Using a series of maps, it describes the agricultural climate of Manitoba, based on the climate in the region over a 60-year period (1929 to 1988).”*

### Print Resources

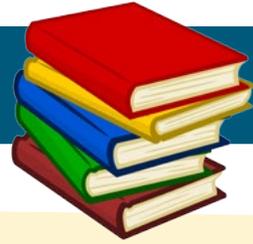
Manitoba Agriculture. *Field Crop Production Guide*. Winnipeg, MB: Province of Manitoba, 2017.

*“The Field Crop Production Guide published by Manitoba Agriculture offers current production information on Manitoba crops such as barley, oats, rye, triticale, wheat, canola, flax, sunflowers, faba beans, field beans, field peas, lentils, forage crops, buckwheat, canary seed, caraway, coriander, corn, mustard, soybeans and some of Manitoba’s newest crops such as amaranth, azuki bean, borage, chickpea, dill seed, fenugreek, lathyrus, lupin, mung bean, proso millet, quinoa, safflower and spelt.”*

Manitoba Agriculture. *Soil Management Guide*. Winnipeg, MB: Province of Manitoba, 2017.

*“This guide focuses on three key principles:*

- Keeping the soil in place by reducing tillage practices
- Maintaining or improving soil quality parameters, such as organic matter, bulk density, earthworms, and desirable soil structure
- Managing and protecting water supplies”



Wright, Ronald. *A Short History of Progress*. Toronto, ON: House of Anansi Press, 2004.

This book is a series of five lectures by Ronald Wright about societal collapse. He concludes that the collapse of human civilization is imminent if we do not act now to prevent it: “now is our chance to get the future right.”

Diamond, Jared. *The World Until Yesterday: What Can We Learn from Traditional Societies?* New York, NY: Penguin Books, 2013.

This book surveys the history of human societies to answer the following question: “What can we learn from traditional societies that can make the world a better place for all of us?”

Diamond, Jared. *Guns, Germs, and Steel*. New York, NY: W.W. Norton, 1999.

This book argues that the modern world has been shaped by geographical and environmental factors, and that food-producing societies were able to use that technological advantage to conquer other cultures.

Diamond, Jared. *Collapse: How Societies Choose to Fail or Succeed*. New York, NY: Penguin, 2014.

Diamond examines ancient societies, including the Anasazi of the American Southwest and the Viking colonies of Greenland, as well as modern ones such as Rwanda, and explains why they failed.

Montgomery, David R. *Dirt: the Erosion of Civilization*. Berkeley, CA: University of California Press, 2007.

Montgomery traces the history of agriculture, showing how historical societies collapsed or moved on when they exhausted the soil. He then argues that moving on is not an option for future generations.

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