MARK TWAIN MEDIA PUBLISHING COMPANY
CD-404142

MIDDLE GRADES

Using STEM to Investigate Issues in FOOD PRODUCTION

Integrated activities that cultivate an interest in **science**, **technology**, **engineering**, and **mathematics** and encourage students to explore careers in these fields

SUPPORTS NCTM STANDARDS

State, National, & Provincial CORRELATED Standards

SUPPORTS NSE STANDARDS

By Barbara R. Sandall, ED. D. and Abha Singh, Ph.D.

MARK TWAIN MEDIA/CARSON-DELLOSA PUBLISHING LLC

Table of Contents

Introduction to *Using STEM to Investigate Issues in Food Production* iii

Introduction to the Series iii

Science, Technology, and Society iii

Technological Design Process iv

Mathematical Problem Solving v

Introduction to Food Production v

Chapter One: Food Production Issues 1

Chapter Two: Biologically Productive Land & Water 16

Chapter Three: Food Systems, Chains, & Webs 34

Chapter Four: Food and Energy 45

Chapter Five: Farming 55

Chapter Six: Hydroponics 68

Chapter Seven: Food Processing & Preservation 83

Chapter Eight: STEM Design Challenge 94

APPENDICES

Science Inquiry Skills Assessment 102

Assessment of Technological Design 104

Science Process Skills 105

National Science Education Standards (NSES) 106

Principles and Standards for School Mathematics (NCTM) 111

International Standards for Technological Literacy (ITEA) 113

Assessment Answer Keys 117

References 118

Chapter One: Food Production Issues

Teacher Information

Topic: Issues in food production

Standards:
NSES – Unifying Concepts and Processes
Systems, Order, and Organization
Form and Function

NSES – Content
NSES A: Science as Inquiry
NSES B: Physical Science
NSES C: Life Science
NSES D: Earth and Space
NSES E: Science and Technology
NSES F: Personal and Social Perspectives
NSES G: Science as a Human Endeavor

NCTM:
Problem Solving
Communication
Reasoning
Mathematical Connections
Probability

ITEA:
Nature of Technology
Technology and Society
Technological World

Concepts:
Food production
Issues in food production, i.e., need for production of food; sustainable development; policies; organic gardening; green food production; food processing; food distribution; amount of land and water resources that are productive; population growth; livestock production; transportation of food; impact on the environment; chemical herbicides, pesticides, and fertilizers; etc.

Objectives:
Students will be able to…

- Examine their own beliefs and values to make decisions related to food production.
- Debate the issues, respecting the rights of others to maintain different rights and values.
- Evaluate possible solutions to food production issues.
- Explain what needs to be considered when making decisions about managing food production.

Activity – Food Production Issue Discussion Sheets (p. 6–12)

Materials:
Issue Discussion Sheets

TEACHER NOTE: The major purpose of this activity is to help students learn about the issues involved in food production. Prior to starting, the teacher should discuss the rules for discussion (i.e., all students have the right to their own opinions, they will listen to and respect each other's ideas, etc.). Reproduce the number of sets of sheets needed for groups of four students. Each group should have a set.

Chapter One: Food Production Issues

Student Information

Topic: Issues in food production

Concepts:
Food production
Issues in food production, i.e., need for production of food; sustainable development; policies; organic gardening; green food production; food processing; food distribution; amount of land and water resources that are productive; population growth; livestock production; transportation of food; impact on the environment; chemical herbicides, pesticides, and fertilizers; etc.

Objectives:
Students will be able to…

- Examine their own beliefs and values to make decisions related to food production.
- Debate the issues, respecting the rights of others to maintain different rights and values.
- Evaluate possible solutions to food production issues.
- Explain what needs to be considered when making decisions about managing food production.

Content Background:

Over 6.8 billion people live on Earth, with some 7 million people being born every month. By 2012, over 7 billion people will be sharing the same land, water, and air. It is difficult for the planet to support this many people, and as a result, over 925 million people live in chronic hunger, which means that they never get enough food to eat.

Food scientists struggle to increase the amount of food produced. There are two sides to the food production issue. One side believes that every food production system should be as efficient and as productive as possible. It should keep the food prices low and maintain adequate reserves for bad crop years. Some believe the

only way to feed a growing population is with genetically modified crops that produce more grain while using chemical pesticides and fertilizers to increase output. Some people believe giving artificial growth hormones and antibiotics to animals will produce more and better meat.

The other side of the food production debate encourages local food and sustainability. Newer scientific studies recommend sustainable farming as a better way. The U.S. Working Group on the Food Crisis report *Can Sustainable Agriculture Feed the World?* recommends that an investment should be made in sustainable agriculture.

Sustainable agriculture or **agroecology** (the science of sustainable agriculture) combines scientific methods with local farming knowledge to create diverse and productive food production systems without relying on expensive seeds and chemicals. Modern agriculture, using current science, technology, and engineering, has allowed more food to be grown and more fresh foods distributed all over the world. However, the current methods used in commercial agriculture are not a sustainable system.

International assessments done by the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) in 2008 indicated that conventional

Chapter One: Food Production Issues

Student Information

industrial agriculture degrades soils and other natural resources and threatens water, energy resources, and the global climate. A United Nations Environment Program confirmed their findings. Both studies encourage the development of sustainable food production.

Agricultural engineers identify, investigate, and solve problems related to food and livestock production. Issues related to food production include land and water use; kinds of farming; food distribution; food processing; food safety and preservation; politics and money; a growing population; and food production sustainability.

U.S. farmers are trying to balance sustainable farm practices with higher productivity. Those involved in U.S. crop production have given increased attention to the impact of farming on the environment due to new technology, chemicals, and seed development. Kinds of farming practices such as organic, chemical, crop rotation, small farms, and industrialized farms are all major issues in food production.

The amount of usable land and water on Earth is very small. Earth has a surface area of 51 billion hectares (2.47 acres in one hectare). This is the amount of land that provides food, water, and other resources. If you look at a globe, 28% of the surface is land and the other 72% is water. Of the 28% that is land, 19% is biologically productive; the other 9% is only marginally productive or unproductive.

Land is **biologically productive** if it is fertile enough to support agriculture, forests, or animal life. The marginally productive or unproductive land includes pavement, land covered by ice, land that has no water, or land that has unsuitable soil conditions for plant growth.

Of the 72% of Earth's surface lakes and oceans, only 4% is biologically productive for human use. The other 68% is marginally productive or unproductive water. The productivity may be reduced by destruction of coral reefs, oil spills, overfishing, and shoreline development.

Of the 51 billion hectares of surface area including land and water, only about 23% is biologically productive. This is the only area we have to produce our food, materials, and energy, and to absorb our wastes. We also share this area with 10 million other species.

Recent changes in global weather patterns have brought new challenges to food production. Desertification is one challenge. **Desertification** is the erosion of formerly productive land into deserts. The most famous example of desertification in the United States was the Dust Bowl in the 1930s. Due to poor farming techniques and a long drought, much of the land in Kansas, Oklahoma, and Texas literally blew away. Today, desertification is causing the Sahara desert to expand south across Africa at a rate of 48 km per year. This land goes from being biologically productive to unproductive.

When more land is cleared for farming by removing trees and bushes, the topsoil blows or washes away, causing a need for more chemicals to be added to add necessary nutrients. If land is used over and over for the same crops, all of the nutrients in the soil disappear. One way to avoid this is by adding chemical fertilizers. However,

Chapter One: Food Production Issues

Student Information

chemical fertilizers, pesticides, and herbicides are getting into our lakes, streams, rivers, and other water resources from groundwater contamination around fields and in the runoff from fields.

A **food system** includes all of the steps in food production from farm to table. The food is grown, shipped, processed, shipped again to markets, purchased in stores, transported home by consumers, and eaten. The energy needed includes not just the energy related to growing the food but also for transportation, processing, preserving, planting, and harvesting.

More food is needed to support the increasing population of the world. Some of the solutions to this food shortage are to use more land, add either organic or chemical fertilizers to marginally productive land to enrich the soil, use chemical herbicides and pesticides to increase crop production, and use genetically engineered crops. Small local farms are being replaced by large corporate farms in an effort to produce more food.

To meet the meat needs required by so many people, large livestock confinements are used to produce more meat. In these lots, livestock are sometimes given antibiotics to reduce the chances of infections and hormones to increase growth or milk production. There is some evidence now that these antibiotics and hormones are getting into the human food supply.

Bringing in food from other countries creates new problems. Farmers in other countries may not use the same standards that the United States requires. For example, Brazil uses chemicals that are banned in the U.S. and the European Union because they are harmful to the environment and humans.

Some believe that returning to local organic farms is the best way to get the best foods to the people and support local economies. Organic farming minimizes the use of synthetic fertilizers and pesticides, which reduces agricultural pollution and reduces the amount of chemicals consumers ingest. Organic farming also uses less fossil fuels and more locally available resources, making it better for the planet. Organic farming doesn't use genetically modified crops, but instead uses local varieties.

One possible solution to the food production problem is the use of hydroponics. **Hydroponics** refers to plants growing without any kind of soil. Plants can grow in other mediums. Some of these mediums include water with nutritional substances added, husks of coconuts, gravel, or mineral wool.

Soil contains nutrients that plants need to grow and provides support to the roots and plant. When it rains, these nutrients are dissolved in water and carried to the plant through the roots. The type of soil and the amount of nutrients in the soil determine how much of the nutrients the plants can absorb and how well it grows.

In hydroponics, nutrients can be dissolved in water and directly absorbed into the roots. The amount of nutrients can be formulated so that the plant can always take in exactly the nutrients that it needs to grow.

Food preservation and processing are an important part of food production. **Food processing and preservation** means the processes by

Chapter One: Food Production Issues

Student Information

which raw food is made suitable for cooking, eating, storing, marketing, and extending their shelf life. In areas where crops cannot be grown year around, there has to be some way to store food to use during the winter months when food cannot be grown.

Historically, fish and meats were dried or salted to preserve them. Louis Pasteur developed the pasteurization process for wine and milk, which killed the organisms that caused foods to spoil. In the 19th and 20th centuries, food preservation was done by heating and sealing foods in jars or cans and by freezing foods to keep them from spoiling.

Food distribution is one of the major issues in food production. **Food distribution** includes local and regional food systems, food miles, energy costs, transportation, oil, etc. One problem in the distribution of food is that not all crops can be grown in all areas, so the only food available in an area are the foods that can be grown in that area. For example, oranges cannot be grown in colder climates.

Since not all food is grown locally, some food is transported from other parts of the world. Ways of preserving food for extended periods of time and carrying it through different temperatures needed to be developed. One way to preserve the food longer and make it easier to transport is by processing the food before it is shipped. Food processing can be done by heating, freezing, pasteurizing, and adding chemical preservatives.

The processing and preservation of foods helps improve food safety. However, it creates other problems in the food system and for the environment. It requires more natural resources such as water, fossil fuels, and land. Packaging and processing food creates more problems with waste management. These packaging materials break down slowly, and the chemicals from these packages and preservation processes can become highly concentrated in our water, air, and soil.

A **sustainable food system** protects or enhances biodiversity, enriches soil, and protects water quality. If the natural systems that provide humans with oxygen, soil, the absorption of carbon dioxide, clean water, and biodiversity are destroyed, the earth will not support life. A sustainable food system avoids using man-made chemicals that stay in the environment longer than a few days.

Man-made substances and chemicals are not easily broken down by natural Earth cycles. They sometimes accumulate in the environment and damage the air, water, and soil. A sustainable food system should not use a lot of plastic packaging, which comes from fossil fuels, or it should develop a way to recycle all packaging.

A sustainable food system must feed all people. It should not feed one community at the expense of others. Resources should be distributed more evenly to all people. Currently, some groups of people around the world are starving while other groups of people are becoming obese because of an overabundance of food. A sustainable food system should use resources efficiently and recycle or reuse wastes.

This book will explore how to develop a sustainable food system to feed the growing population of the world.