Environmental Literacy Model

Title	Farming the Future
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School, District	Anne Arundel County Public Schools
Audience (grade, course)	Earth/Space Science (10th - 12th grade)

Curriculum Anchor

Defining the Learning Objectives and Curriculum Connection

Curriculum indicators, performance expectations, and/or student learning objectives.

NGSS

Performance Expectations

HS-ESS3-2.Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: Assessment for computational simulations is limited to using provided multiparameter programs or constructing simplified spreadsheet calculations.]

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

Science and Engineering Practices

SEP: Using Mathematics and Computational Thinking
SEP: Analyzing and Interpreting Data
SEP: Constructing Explanations and Designing Solutions

Cross Cutting Concepts

CCC: Stability and Change

Environmental Literacy Standards

STANDARD 1 ENVIRONMENTAL ISSUES

The student will investigate and analyze environmental issues ranging from local to global perspectives and develop and implement a local action project that protects, sustains, or enhances the natural environment.

Topic A: Environmental Issue Investigation

Indicator 1: Identify an environmental issue. Indicator 2: Develop and write research questions related to an environmental issue. Indicator 3: Given a specific issue, communicate the issue, the stakeholders involved and the stakeholders' beliefs and values. Indicator 4: Design and conduct research. Indicator 5: Use data and references to interpret findings to form conclusions.

Topic B. Action Component

Indicator 1: Use recommendation(s) to develop and implement an environmental action plan. Indicator 2: Communicate, evaluate and justify personal views on environmental issues and alternate ways to address them. Indicator 3: Analyze the effectiveness of the action plan in terms of achieving the desired outcomes.

STANDARD 5 HUMANS AND NATURAL RESOURCES

The student will use concepts from chemistry, physics, biology, and ecology to analyze and interpret both positive and negative impacts of human activities on earth's natural systems and resources.

Topic A: Human Impact on Natural Processes

Indicator 1: Analyze the effects of human activities on earth's natural processes. Indicator 2: Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes.

Topic B: Human Impact on Natural Resources

Indicator 1: Analyze, from local to global levels, the relationship between human activities and the earth's resources

STANDARD 8 SUSTAINABILITY

The student will make decisions that demonstrate understanding of natural communities and the ecological, economic, political, and social systems of human communities, and examine how their personal and collective actions affect the sustainability of these interrelated systems.

Topic A: Intergenerational Responsibility

Indicator 1: Understand and apply the basic concept of sustainability to natural and human communities.

Topic B: Interconnectedness of Systems

Indicator 1: Recognize the concept of sustainability as a dynamic condition characterized by the interdependency among ecological, economic, and social systems and how these interconnected systems affect individual and societal well-being.

Topic C: Influence of Economic Systems on Sustainability

Indicator 1: Investigate and make decisions that demonstrate understanding of how the dynamics of economic systems affect the sustainability of ecological and social systems.

Topic D: Influence of Social and Cultural Systems on Sustainability

Indicator 1: Investigate and make decisions that demonstrate understanding of how the dynamics of social and cultural systems affect the sustainability of ecological and economic systems.

Topic E: Limits of Ecological Systems

Indicator 1: Investigate and make decisions that demonstrate understanding of how the dynamics of ecological systems affect the sustainability of social, cultural systems and economic systems.

Topic F: Action Component

Indicator 1: Apply knowledge and skills to investigate and implement personal and collective decisions and actions on an individual, local community, national, and global levels in order to achieve sustainability.

Student Learning Objectives

Students will understand that:

- different farming practices yield different amounts of produce/livestock
- factors such as water usage and soil health impact crop productivity

Students will know that:

- sustainable crops require proper soil health, water, and nutrients to be productive
- urban areas are able to produce crops through creative designing and planning
- food production for a growing population take planning
- organic gardening allows for maintenance of healthy soil
- different farming practices (organic vs. monoculture) leave different nutrients in the soil for plants to use

Students will be able to:

- explain the basic principles of sustainability
- research sustainable/urban farming practices
- identify strategies for agricultural sustainability that meets the needs of human populations over time
- identify strategies that improve the sustainability of farming practices using the PBS City Farm game.
- collect data about crop cost, surplus value, farm share, soil health, water needs, and sustainability.
- use a computational simulation to model sustainable farming practices
- conduct simple soil testing

Describing the Local Context

The life-relevant issue that will serve as the context for learning.

Anne Arundel County is a densely populated area with communities ranging from urban to suburban living. Farms exist within the county boundaries, but do not produce enough food to sustain the current human population. Farming systems contribute varying amounts of nutrient and sediment pollution to the watershed, and conserve or reduce soil depending on their design. Though food deserts have not been defined within the county limits, some students live in areas with limited access to unprocessed, high nutritional value, foods.

We aim to guide students to design and create sustainable food production systems that minimize negative impacts on soil and water quality, use less energy resources, and promote healthy food choices.

Identifying the Driving Question

A broad, open-ended, life-relevant question that is based on the standards/learning objectives. Guides inquiry for the investigation(s), prompts the development of actionable claims.

How can we improve the sustainability of food production in Anne Arundel County in order to minimize the negative impacts on soil, water quality, and energy use?

Issue Investigation		
Asking Questions, Defining Issues and Problems Students define the issue, problem, or phenomenon to be investigated and develop supporting questions that are relevant for investigation.		
Issue Investigation 1	**Issue Investigation 2**	**Issue Investigation 3**
What sustainable terrestrial farm models already exist in urban areas around the world? How do these farming models impact natural resource use and food production?	To what extent do current terrestrial farming systems impact soil quality and contribute to soil loss?	To what extent do various terrestrial farming systems impact the water flow and water quality of the Chesapeake Bay Watershed system?
Planning and Conducting Investigations Students plan and conduct investigations and classroom activities (indoor and outdoor) that actively address students' supporting questions. Students collect data that will be used to inform actionable claims.		
Issue Investigation 1	**Issue Investigation 2**	**Issue Investigation 3**
1. Brainstorm prior knowledge of farming and sustainability. What do students know/think about those terms? Create a double bubble or other thinking maps about sustainability and farming. eacher note: This unit focuses on terrestrial food production systems, not aquaculture. 2. Students view a Discovery Education Video, "*Urban Farming*". 3. Students discuss how the urban rooftop farms are solutions to environmental sustainability for Singapore. 4. Discuss numbers of food insecure families in Anne Arundel county or Maryland Teacher Note: Play Map Overview for your class. [Hunger & Poverty in Maryland] 5. Using the City Farm	1. Review research from issue investigation 1. What types of farms did students find out about? 2. Skype/Google Meet with a local farmer or arrange field trip to tour a local farm (Maryland Sunrise Farm, Gambrills; Claggett Farm, Upper Marlboro; Farm on Jug Bay owned property, Lothian; Langton Green Community Farm, Millersville) to discuss current farming practices and tie in social cultural aspects of farming such as history and economy. Options: Go to or discuss local farmers markets. Ask students what they have purchased, what they notice. Or, Skype/Google Meet with a farmer in another country such as El Salvador to create multi-cultural connections. 3. Students will research the	1. Review thinking maps created at the beginning of the unit. Add new knowledge using a different color. Ask students what they have learned so far and prompt them to wonder about possible impacts on the Chesapeake Bay watershed. Make a circle map with the words "Chesapeake Bay Water" in the center. Around the circle have students write word clusters and draw images describing water and how we test water OR make a double bubble map with Good Water Quality on one side and Poor Water Quality on the other 2. Students use National Geographic or ARC GIS maps to identify tributaries closest to each farming system studied 3. Students obtain water samples from various points along the tributaries, both above and

Computer Simulation, students model sustainable farming by varying the amount and location of crops in a farm plot. https://www.pbslearningmedia.org/resource/sust13.sci.eco.cityfarm/city-farm/#.XjdrtmhKjIU 6. Make a connection back to the Hunger and Poverty in Maryland website. Lead students to ask about how important farms are in preventing hunger and what types of farms exist. 7. Research urban farming and water conservation techniques. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/md/home/?cid=nrcs144p2_027111	difference between monoculture farming practices and organic farming practices such as multi-crop or mixed arable-pastoral farms. 4. Students will learn how to use soil testing kits in the classroom from soil taken from a natural area near the school. Students will compare the types of nutrients left in the soil (or lack thereof) for plants to use in a monoculture farm vs. organic farm. Teacher note: teachers may have to request soil samples from area farms if field trips are not an option. 5. Students will learn how to conduct a percolation test in the same natural area near the school. Teacher note: If a percolation test cannot be performed outside, an indoor version can be used with soil samples. 6. Students will design and carry out an investigation that compares the soil health between a monoculture farm, an organic farm, and an area on the school grounds that might be a good location for a garden. Choose farms close to the school that will allow student groups. Soil test parameters will depend on the soil kit, but may include pH, nitrogen, and phosphorus. The teacher can choose a simple percolation test to conduct at all three locations. 7. Hold class discussion to compare findings from field or class soil investigations to the "City Farm" simulation. 8. Extension: Students design and carry out a field investigation about possible soil degradation and the extent to which each farming	below the farms. 4. Teachers will select the aquatic health measurement to be studied. Ideas for data collection include turbidity, nitrates, phosphates, pH, dissolved oxygen. For students who excel or wish to pursue an independent investigation the BOD of a local pond could be found using a five-day protocol. Teacher note: Studies other than DO can be done in the classroom if necessary, by obtaining ample water samples ahead of time. 5. Extension: Students investigate physical characteristics of streams such as slope and flow rate. Teacher note: reference DNR's explore and restore stream curriculum. https://dnr.maryland.gov/education/Pages/GeomorphicProperties.aspx

	system contributes to the issue, or students can measure CO_2 emissions to study soil microbes.	

Issue Investigation (can't.)

Analyzing and Interpreting Data

Students analyze data through graphs, models, and other methods to reveal patterns and relationships. Students synthesize and apply evidence from their investigations to draw conclusions that address the supporting questions.

Issue Investigation 1	Issue Investigation 2	Issue Investigation 3
1. Students analyze strategies which can be implemented to improve the sustainability score for the garden plot. 2. Students analyze how performance of the plot changed throughout the 3 trials. 3. Students interpret their results and develop three principles for how to farm sustainably. 4. Students relate how there could be solutions for our area. 5. Students evaluate the benefits to urban gardening including cost and benefit.	1. Students will analyze the results of soil testing from the three different locations. Nitrogen, Phosphorus and pH levels will be analyzed. Students may also wish to investigate the oxygen content of the soil. Extension: Students analyze data about soil degradation, or analyze data and observations about soil microbes.	1. Students will produce digital maps using ESRI (arc GIS) or hand drawn maps to show the tributaries and their path to the Bay. Arts Integration: Students may use watercolor techniques or storytelling to illustrate the addition of pollutants to the watershed. 2. Students will analyze all data collected from tributaries and will create a series of charts and graphs to illustrate differences among water quality indicators.

Constructing and Communicating a Claim

Students draw on the conclusions from their investigations to make a claim about the driving question and communicate these evidence-based claims to internal and/or external audiences.

Issue Investigation 1	Issue Investigation 2	Issue Investigation 3
Students conclude that managing natural resources such as soil health and water needs play an important role in producing sustainable crops.	After comparing nitrogen, phosphorus and pH levels, students will make claims about the soil health of various farms Note: Ideally claims will be made about soil health both before and after growing season in order to evaluate the impact each farming system has on soil quality. Extensions: Students that need a challenge could make claims about possible soil degradation or soil health based on microbes. Teachers may wish to challenge students to connect soil degradation to turbidity during the third investigation.	Using information from charts and graphs, students will make claims about the impact of various farming practices on water quality in the watershed. Teacher note: Provide a variety of platforms for communication of this data including formal writing, video or other digital visual display, and presentation boards. Final Analysis: Students will compare water quality and soil quality results, as well as the results of investigations regarding resource use, to determine the most sustainable terrestrial food production system for their area. Lead students to look at data

		collected throughout all three investigations to make decisions about the benefits and possible negative impacts of farming systems explored. Consider social and cultural concerns in final analysis. See teacher note above for communication choices.

Stewardship and Civic Action

Identifying Solutions

Students identify and explore solutions that directly address the problem, challenge, or opportunity reflected in their claim. Students use decision making processes to identify the solution(s) to implement.

Students will determine the most sustainable terrestrial system for growing food locally, in either their school, neighborhood, public area such as a library, or their own home. Students will utilize research about urban farming and water conservation techniques from the first investigation in order to make a claim about the "best" farming system(s) and will create a plan to mitigate any negative impacts of their chosen farming type to soil or water systems.

Students will work independently or with a partner or small group to design and develop an action project.

Ultimately students will develop their own project ideas, but examples of student action projects could include, but are not limited to, rain barrels, vegetable garden on school grounds, composting, vertical garden, hydroponic system or other alternatives to traditional and modern agricultural systems.

Students may also consider the installation of stream buffers, soil tiering and other mitigation systems as their action project.

Designing a Plan and Taking Informed Action

Students design a plan for implementing solutions through informed action in their classrooms, schools, and/or communities. The plans should include criteria for determining the extent to which the action successfully addresses the problem, challenge, or opportunity reflected in the claim. Students implement their plans.

Students will work independently, in partnership or in teams to complete a two-part project. The first part focuses on informing community members and stakeholders about their findings. The second part focuses on engineering design, allowing for student choice in designing and building a model or full-scale solution.

Part 1: Students will produce a public service campaign to describe the benefits of the agricultural system they deemed most sustainable. The aim is to build awareness of best farming practices and possible local food production. Their campaign will include a description of the findings from their investigations as well as an explanation of the various environmental impacts associated with arable and pastoral farming. Teachers will lead students to include the benefits of minimizing food miles and purchasing food from local farms.

Option 1: Students record PSA for KRAB radio. Be sure to have students argue why they chose their selected system (s).

Option 2: Students contact local congressperson as described in Feeding America, and/or volunteer at the Maryland Food Bank https://map.feedingamerica.org/congressional/2017/overall/maryland

Part 2: Students develop a detailed plan for urban gardening (if they are in urban or densely suburban schools), sustainable small-scale arable farming (if the school serves less densely populated areas), or for the mitigation of impacts from an existing local farm.

Students will present their plan to the school's Green/Environmental Club, Principal, or School Board.

Students/student teams will build a model or full-scale prototype of a sustainable food production system or mitigation (or both).

With permission, students install a prototype of the farming system and/or mitigation on school grounds, a local library, or other community area.

Fruit or vegetables grown could be offered to students during lunches or offered to students in gardening or green clubs.

Evaluating Action

Students reflect on the action and determine the extent to which it successfully addresses the problem, challenge, or opportunity reflected in the claim. Students communicate their findings and share proposals for sustaining or extending the action.

Students will share their public service campaigns and will peer review and peer evaluate their perceived effectiveness. If the school has a partnership with an advertising firm, teachers could put the campaigns on display to have the advertising agents provide feedback.

Effectiveness of the gardening system could be measured by the mass of food produced.

Extension: Students analyze cost effectiveness of their system comparing the monetary resources necessary to build and implement versus the mass of food produced. Students could make a prediction about the number of years it would take to "break even".

Effectiveness could also be measured by community interest. Students will leave a QR code, or e-mail address or other interactive form of technology in order for community members to request information about how to install their own urban garden. The amount of interest would be correlated to effectiveness.

If students choose to create stream buffers or other mitigations, they could develop a procedure to test its effectiveness in the future.