HS.ESS-HS Human Sustainability

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Students who demonstrate understanding can:

a. Construct arguments for how the developments of human societies have been influenced by natural resource availability including: locations of streams, deltas, and high concentrations of minerals, ores, coal, and hydrocarbons.

b. Reflect on and revise design solutions for local resource development that would increase the ratio of benefits to costs and risks to the community and its environment. [Clarification Statement: Examples of local resource development include soil use for agriculture, water use, mining for coal and minerals, pumping for oil and natural gas.]

c. Construct scientific claims for how increases in the value of water, mineral, and fossil fuel resources due to increases in population and rates of consumption have sometimes led to the development of new technologies to retrieve resources previously thought to be economically or technologically unattainable.

d. Construct scientific arguments from evidence to support claims that natural hazards and other geologic events have influenced the course of human history. [Clarification Statement: Famines that result from reduced global temperatures can follow large historic volcanic eruptions. Large earthquakes and tsunamis can destroy cities, and there is a strong correlation between historic climate changes and the number of wars.]

e. Construct scientific claims about the impacts of human activities on the frequency and intensity of some natural hazards. [Clarification Statement: Natural hazards to include floods, droughts, forest fires, landslides, etc.]

f. Identify mathematical relationships using data on the rates of production and consumption of natural resources in order to assess the global sustainability of human society. [Assessment Boundary: Students construct equations for linear relationships, but not expected to construct equations for non-linear relationships.]

g. Construct arguments about how engineering solutions have been and could be designed and implemented to mitigate local or global environmental impacts. [Clarification Statement: Environmental impacts to include acid rain, water pollution, the ozone hole, etc.]

h. Use results from computational General Circulation Models (GCMs) to investigate how the hydrosphere, atmosphere, geosphere, and biosphere are being modified in response to human activities.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. (h)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Students also use and create simple computational simulations based on mathematical models of basic assumptions.

- Use mathematical expressions to represent phenomena or design solutions in order to solve algebraically for desired quantities. (f)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories) and peer review. (c),(d),(e),(g)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world. Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning of currently accepted explanations or solutions as a basis for the merits of the arguments. (a)
- Criticize and evaluate arguments and design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. (b)

Disciplinary Core Ideas

ESS3.A: Natural Resources

- Resource availability has guided the development of human society. Resource availability affects geopolitical relationships and can limit development. (a)
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (b)
- As the global human population increases and people's demands for better living conditions increase, resources considered readily available in the past, such as land for agriculture or drinkable water, are becoming scarcer and more valued. (c)

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history by destroying buildings and cities, eroding land, changing the courses of rivers, and reducing the amount of arable land. These events have significantly altered the sizes of human populations and have driven human migrations. (d)
- Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. Human activities can contribute to the frequency and intensity of some natural hazards. (e)

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (f)
- Scientists and engineers can make major contributions–for example, by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. When the source of an environmental problem is understood and international agreement can be reached, human activities can be regulated to mitigate global impacts (e.g., acid rain and the ozone hole over Antarctica). (g)
- Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities and changes in human activities. (h)

Crosscutting Concepts

Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects. (d),(h)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering and Technology
Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (c)

Influence of Engineering, Technology, and Science on Society and the Natural World
Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications. Engineers continuously modify these systems to increase benefits while decreasing costs and risks. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (a),(b),(e),(f),(g)

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Connections to other DCIs in this grade-level: **HS.LS-IRE, HS.PS-CR, HS.PS-E, HS.ETS-ETSS**	
Articulation to DCIs across grade-levels: **K.WEA, 3.WCI, 4.PSE, 4.E, MS.ESS-WC, MS.ESS-EIP, MS.ESS-ESP, MS.ESS-HI**	
Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]	
ELA –	
W.9-10.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
W.9-10.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.9-10.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
WHST.9-10.1	Write arguments focused on discipline-specific content.
W.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
SL.11-12.2	Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data
W.11-12.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
W.11-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
WHST.11-12.1	Write arguments focused on discipline-specific content.
Mathematics –	
MP.2	Reason abstractly and quantitatively
MP.3	Construct viable arguments and critique the reasoning of others
MP.4	Model with mathematics
F.IF	Interpret functions that arise in applications in terms of the context
F.BF	Build a function that models a relationship between two quantities
F.LE	Construct and compare linear, quadratic, and exponential models and solve problems
G.MG	Apply geometric concepts in modeling situations
A-CED.1	Create equations that describe numbers or relationships
S.ID	Summarize, represent, and interpret data on a single count or measurement variable; Summarize, represent, and interpret data on two categorical and quantitative variables
S.IC	Make inferences and justify conclusions from sample surveys, experiments, and observational studies