

Appendix A: 2025 ESA EcoEdDL Learning Activity

2025 ESA EcoEdDL Learning Activity

Title: *Food Energy Water Nexus Challenge: A Case Study Analysis*

Abstract:

The activity assignment is designed to be the cornerstone project of an undergraduate course. It is flexible and could be assigned, with or without modifications, in courses in ecology, environmental studies, environmental science, environmental planning, environmental history, and more. It can be used effectively in face-to-face or online courses. Students and faculty do not need to have a previous understanding of the food energy water (FEW) nexus or the 4DEE framework to prove successful at this exercise.

This assignment is a case study analysis asking students to select a place-based circumstance and apply the FEW framework to identifying barriers and solutions in the name of finding sustainable solutions. Case studies analysis facilitates critical thinking within the field of environmental studies and sciences. Through this assignment and the supplemental materials, students will ultimately be able to assess the ecological characteristics of an FEW challenge, determine approach points of divergence and conflict, assess stakeholder objectives, and develop sophisticated approaches to equitable problem-solving.

This Learning Activity contains (1) a written project description, and (2) five associated PowerPoint slide decks. The project is based on an assignment previously used in a classroom setting, but has been revised to be much more comprehensive. It can be shortened or extended to meet instructional needs. The slide decks cover the following topics: (1) Food Energy Water Nexus Overview, (2) Ecology, (3) Water Use and Ecology, (4) Food Issues and Ecology, and (5) Agriculture and Ecology. In tandem, the materials can be used to teach FEW principles within the 4DEE framework, and guide students in applying what they have learned to a real-world case study.

Learning objectives

- Situate the Food Energy Water nexus within the context of the Four-Dimensional Ecological Education Framework (4DEE).
- Utilize the ecological underpinnings of the FEW nexus to gain a deeper understanding of way in which food, energy, and water are intrinsically interconnected.
- Apply the FEW nexus to an applied scenario through in-depth research of a regional case study, using the principles of case study analysis.
- Evaluate competing alternatives to a chosen case study in terms of trade-offs and be able to identify mutually beneficial outcomes.

- Through recognizing the synergies between aspects of the FEW nexus, identify solutions that address the needs and concerns of all stakeholders that contribute to the principles of sustainability.

Incorporating 4DEE in your Learning Activity

Background

This learning activity includes all dimensions of the 4DEE Framework: Core Ecological Concepts, Ecology Practices, Human-Environment Interactions, and Cross-cutting themes. The dimensions are covered in lectures, provided as supplemental materials. The food, energy, and water components, and how they are inter-related, are framed within the structure of the 4DEE framework. Gaining an understanding of these four dimensions are necessary for successfully completing the learning activity.

Timeframe

Each lecture provides a 20-30 minute framework that can be added to and subtracted from based on instructor needs. The assignment associated with the activity would take ~6 weeks of consistent weekly work in the semester system, and could be expanded or limited in light of course circumstances.

List of materials

No specialized materials are needed for this assignment

Procedure and general instructions (for instructor)

This learning activity is centered on the “Food Energy Water Challenge: Case Study Analysis” Assignment. The instructor should begin by reviewing the assignment with students and answering any questions that arise.

The components of the written assignment are listed as follows:

- Introduction
- The FEW Challenge
- Ecological Context
- In-depth discussion of the food, energy, and water dimensions
- The intersections of food, water, and energy
- Current attempts at problem solving
- Stakeholder analysis
- Recommendations
- Conclusion

It is recommended that the sections of the assignment be submitted with sequential due dates, rather than summatively at the end. This allows the instructor to course-correct should it be needed.

This learning activity also includes five PowerPoint lectures intended to provide students with the FEW nexus, framed within the 4DEE structure, needed to complete the assignment successfully. The lectures should be before or shortly after students begin the assignment, as they equip students to respond to assignment prompts. They are listed in the recommended order, but could be fielded individually or in a different order.

The PowerPoint slide decks are described as follows:

The Food-Energy-Water Nexus: Understanding Interconnections for Sustainability

General description of the FEW, why it matters, a brief discussion of how each aspect of the nexus relates to the other, challenges to the nexus framework, and technologies that can enable the framework's execution.

Understanding Ecology: 4DEE: The Foundation of the Food Energy Water Nexus

Description of the importance of 4DEE, and an overview of each dimension. Discussion of core ecological concepts in the concepts of human-environment interactions, ecology practices, and cross-cutting themes. Concludes with challenges and opportunities for integrating the FEW framework.

Agriculture & Ecology: An Overview within the Four-Dimensional Ecological Education Framework

Description of the importance of 4DEE, and an overview of each dimension. Discussion of the historical significant of agriculture with respect to ecology and social organization. Analysis of agroecosystems, sustainable agriculture, ecological practices within agriculture, and the relationship between agriculture and climate.

Energy & Ecology: An Overview within the Four-Dimensional Ecological Education Framework

Description of the importance of 4DEE, and an overview of each dimension. Role of Energy in the FEW nexus, energy flows in ecosystems, ecology practices and energy, human-environment interactions and energy, non-renewable energy and clean energy, energy equity and energy justice.

Water & Ecology: An Overview within the Four-Dimensional Ecological Education Framework

Description of the importance of 4DEE, and an overview of each dimension. Description of the water cycle, role of water in ecosystems, ecology practices and water, human-environment interactions and water resources, water and sustainability, water and conservation, water access and energy, water and environmental justice.

Procedure and general instructions (for students)

See “Food Energy Water Nexus Challenge: A Case Study Analysis” assignment for all necessary instructions.

Materials for assessing student learning

Instructors can use the FEW 4DEE Pre-Assignment Assessment to assess student familiarity with the 4DEE framework. This is based on the ESA’s definition the components of 4DEE literacy. This could be administered in-class or online. It could also be reassigned after the learning activity has been completed, with or without modifications. Institutional Review Board approval should be obtained as necessary.

Appendix B: Pre/Post Quiz Descriptive Statistics (RQ2)

This appendix contains all quantitative descriptive results from the matched pre/post FEW–4DEE familiarity survey ($n = 7$). Scores reflect student self-reported familiarity on a 1–5 scale. Missing responses were excluded from mean calculations. Gain scores were computed as post – pre.

Domain-Level Means (4DEE Aggregates)

Table I. Mean Pre, Post, and Gain Scores by 4DEE Domain ($n = 7$)

4DEE Domain	Pre Mean	Post Mean	Mean Gain
Core Ecology Concepts	3.29	4.03	0.74
Ecology Practices	2.71	4.21	1.50
Human–Environment Interactions	3.39	4.64	1.25
Cross-Cutting Themes	3.29	4.53	1.24
Overall Average	3.17	4.31	1.14

Table II. Pre, Post, and Gain Scores by Item ($n = 7$)

Item	Pre	Post	Gain
Autecology	3.14	3.86	0.71
Population	3.29	4.29	1.00
Community	3.29	4.14	0.86
Ecosystems	3.43	4.43	1.00

Landscapes	3.57	4.29	0.71
Biomes	3.14	4.14	1.00
Biosphere	3.29	4.29	1.00
Natural History	2.71	4.43	1.71
Fieldwork	2.71	4.43	1.71
Quantitative Reasoning	2.43	4.14	1.71
Designing Investigations	2.43	4.43	2.00
Ecosystem Services	3.29	4.29	1.00
Human-Accelerated Environmental Change	3.43	4.71	1.29
How Humans Shape/Manage Ecosystems	3.29	5.00	1.71
Ethical Dimensions	3.29	5.29	2.00

Appendix C: Frequency of Ecological and 4DEE Elements in 2025 Student FEW Case Study Projects

Table III. Frequency of Ecological and 4DEE Elements in 2025 Student FEW Case Study Projects

Category	Present_n	Present_%
Ecological context (ecosystems/landforms/biota)	14	93.3
Nutrient cycling / water quality / biogeochemistry	6	40
Species & community dynamics	10	66.7
Hydrological processes (surface & groundwater)	13	86.7
Soils & land degradation	8	53.3
Climate & environmental change	10	66.7
Ecosystem services language	0	0
Explicit human-environment interactions	14	93.3
Stakeholders linked to ecological impacts	12	80
4DEE: Core ecological concepts	12	80
4DEE: Ecology practices / data use	8	53.3
4DEE: Human-environment interactions	14	93.3
4DEE: Cross-cutting themes (sustainability, justice, ethics)	10	66.7

Appendix D. Survey Instruments

Pre-Course Fall 2025

Format: Items 1–5 are categorical or open-ended.
Items 6–21 use a **0–5 familiarity scale**.

Familiarity Scale (Items 6–21)

0 = Never heard of this

1 = Not familiar at all

2 = Slightly familiar

3 = Moderately familiar

4 = Very familiar

5 = Extremely familiar

Pre-Survey Items

1. What is your grade level?

- First-year
- Sophomore
- Junior
- Senior
- Other

2. Have you heard of the term “Food–Energy–Water nexus”?

- Yes
- No

3. Regardless of whether or not you have heard of the Food–Energy–Water nexus, what do you know, believe, or think that it is?

(Open-ended)

4. Have you heard of the Four-Dimensional Ecology Education (4DEE) Framework?

- Yes
- No

5. How familiar are you with the following?

(Uses the 0–5 scale above; items 6–21 are individual rows under this umbrella.)

6. Autecology

Examples: abiotic/biotic features, resources & regulators, habitat/niche

7. Population Ecology

Examples: dispersion, exponential/logistic growth, demography

8. Community Ecology

Examples: species interactions, competition, succession, stability

9. Ecosystems

Examples: trophic levels, predation, food chains, energy flow, nutrient cycling

10. Landscapes

Examples: patches, gradients, watersheds

11. Biomes

Examples: biome types, effects of latitude and elevation

12. Biosphere

Examples: global biogeography, global climate change

13. Natural History

Examples: observational approaches, field-based connections

14. Fieldwork

Examples: habitat assessment, ID & preservation, spatial analysis

15. Quantitative Reasoning & Computational Thinking

Examples: statistics, modeling, informatics, data skills

16. Designing & Critiquing Investigations

Examples: study design, evaluating evidence, ecological inquiry

17. Ecosystem Services

(Self-explanatory)

18. Human-Accelerated Environmental Change

Examples: anthropogenic impacts, toxics, climate change

19. How Humans Shape & Manage Ecosystems

Examples: agriculture, urban ecosystems, ecological engineering, conservation

20. Ethical Dimensions

Examples: environmental ethics, sustainability, environmental justice, eco-economics

21. Thank you!

(End of survey)

Post-Course Fall 2025

Format: Items 1–3 are categorical or open-ended.
Items 4–19 use the same 0–5 familiarity scale as the pre-survey.

Familiarity Scale (Items 4–19)

- 0 = Never heard of this
- 1 = Not familiar at all
- 2 = Slightly familiar
- 3 = Moderately familiar
- 4 = Very familiar
- 5 = Extremely familiar

Post-Survey Items

1. What is your grade level?

- First-year
- Sophomore
- Junior
- Senior
- Other

2. In your own words and in one or two sentences, what is the Food–Energy–Water nexus?
(Open-ended)

3. Now that you have completed the project, how familiar are you with the following?
(Uses 0–5 scale; items 4–19 are individual rows.)

4. Autecology

Examples: abiotic/biotic features, resources & regulators, habitat/niche

5. Population Ecology

Examples: dispersion, exponential/logistic growth, demography

6. Community Ecology

Examples: species interactions, competition, succession, stability

7. Ecosystems

Examples: trophic levels, predation, food chains, energy flow, nutrient cycling

8. Landscapes

Examples: patches, gradients, watersheds

9. Biomes

Examples: biome types, effects of latitude and elevation

10. Biosphere

Examples: global biogeography, global climate change

11. Natural History

Examples: observational approaches, field-based connections

12. Fieldwork

Examples: habitat assessment, ID & preservation, spatial analysis

13. Quantitative Reasoning & Computational Thinking

Examples: statistics, modeling, informatics, data skills

14. Designing & Critiquing Investigations

Examples: study design, evaluating evidence, ecological inquiry

15. Ecosystem Services

(Self-explanatory)

16. Human-Accelerated Environmental Change

Examples: anthropogenic impacts, toxics, climate change

17. How Humans Shape & Manage Ecosystems

Examples: agriculture, urban ecosystems, ecological engineering, conservation

18. Ethical Dimensions

Examples: environmental ethics, sustainability, environmental justice, eco-economics

19. Thank you!

(End of survey)