How do farmed animals affect our world?

Secondary: (ages 11-14)	**Science, Technology, Engineering, Maths (STEM)**

In this unit, students investigate the impact of farmed animals on the environment. They engage in investigation and with texts, models and data sets to explore the impact of farmed animals' lives on the world and their communities and generate ideas for mitigation.

Time allocation	About 12 lesson periods
Subject content	Working with large data sets, mathematical reasoning and models, phosphorus, algae blooms, impacts of chemicals on water, biological systems, farmed animals
Creativity and critical thinking	This unit has a **creativity** and **critical thinking** focus: • Seek and explore ideas about how farmed animals impact the environment and for the mitigation of animal waste • Imagine and compare different perspectives on the impact of animal waste • Generate, select, implement, and evaluate ideas for how to investigate the impacts of animal waste on freshwater
Other skills	Collaboration
Key words	Estimate; deduce; average; mass; impact; animal waste; community

Products and processes to assess

Students collect and record data and handle big data sets through estimation and quantitative reasoning. They solve problems involving uncertain numbers and represent data as mathematical models. At the highest levels, students express empathy for animals in writing, and connect mathematics and their daily lives to science contexts to develop evidence-based arguments, whilst also acknowledging assumptions, limitations and remaining uncertainties. They generate several unusual ideas and push some to their limits before making final choices, showing a clear awareness of areas of personal novelty and risk and why final choices were made.

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Teaching and Learning plan

This plan suggests potential steps for implementing the activity. Teachers can introduce as many modifications as they see fit to adapt the activity to their teaching context.

Step	Duration	Teacher and student roles	Subject content	Creativity	Critical thinking
1	Lesson periods 1 and 2	Distribute gummy sweets to the class. Ask if they have any idea what they just consumed. Have students discuss in pairs and then ask for volunteers to share thoughts with the class. Ask if there was any animal product in the sweets, and point out that we sometimes make assumptions about things, including food, without being fully aware we have made those assumptions (e.g. about whether a food does or does not contain animal products). Explain that many gummy sweets do contain gelatine, an animal product, made from pigs. Inform students that these sweets do not contain gelatine. Introduce the students to the driving question (DQ) of the unit (how do farmed animals affect our world?). In pairs, tell students they will recall and record their meals the day before and the week before and note how many instances when they ate animals or animal products. The class, led by the teacher, first develops a definition of animal product and ways to search for ingredients found in the foods they eat. Support students by encouraging them to use resources that they may not realise are available, for example 'I wonder who you could ask to find out what was in the school lunch today?' or 'I wonder if there's someone we could call to find that out' and by asking questions that direct attention to areas students may have missed. Ask students to note any assumptions they make or uncertainties they encounter. Using estimation and multiplication (and a calculator) students multiply the number of times they ate animal products last week by the number of people in their community. They record the estimate of the number of animals involved in a shared document. Ask students if they think this number from the group of students is representative of the choices in the community and how useful they feel	Number properties and operations. Number sense. Difference between known, guessed and estimated numbers.		Inquiring: Observe, describe relevant experiences. Identify and question assumptions about animals and animal products. Become aware of gaps in knowledge.

		such estimates are. Solicit many responses and press for reasoning, including any assumptions they have made in the process and why. The teacher provides reassurance and support for students who are uncomfortable with maths problems that don't have definite answers. Each group brainstorms questions related to the day's class, and then each member of the group selects one question to present to the class. Organise questions according to categories (which students generate) as a class.			
2	Lesson period 3	Small groups use the numbers previously generated for a week to come up with a number to express the farmed animals consumed in the community over a day and a year. As a class, look for wildly divergent numbers (and discuss what thinking processes might have led to these differences), check for errors in numerations and ask students to note assumptions made, and whether alternative assumptions might lead to different results. Return to questions about whether the students represent typical consumers in the community (and why/why not) and adjust the number accordingly. Explain and discuss methods of sampling and sample bias such as undercoverage bias. Then average out the answers for a final guess at the number of various farmed animals consumed in the community, making sure that students can articulate the limits of this approach. Discuss if that number represents the number of animals that they see around them and if not, where the animals are. Add more questions to the Driving Question Board.	Checking for approximate accuracy and validity. Sample bias.	Inquiring: Make connections between animal consumption and the characteristics of the local area.	Inquiring: Understand the context, frame and boundaries of the problem to estimate number of farmed animals consumed. Identify and question assumptions.
3	Lesson periods 4 and 5	Explain to students that in order to answer the driving question (see title), they need to consider the impact the animal's life has on the environment. Brainstorm as many ways as possible that a farm animal might impact the environment, encouraging students to think beyond the obvious. Lead a discussion about animal waste, does anyone know what happens to animal waste? Gather students' background knowledge. Have student groups select an animal that is commonly eaten and research information (online or in provided textbooks and materials) about what happens to the waste produced by the animal. Then, the groups work out an	Impact of animal waste on the environment. Learning about interconnected environmental impacts of animal waste.	Imagining: Generate and explore ideas about how farmed animals might impact the environment.	

		estimate for <u>how much waste</u> their animal produces in a year, multiplied by the estimated number of animals eaten in a year in the community. The groups carry out research to respond to the questions, 'What happens to all this waste?' and 'What is the impact of the waste on the environment, and on nearby communities?' and "What solutions are being attempted for these problems?' The teacher supports students in finding and accessing resources, pointing out omissions and explaining concepts or scientific processes as they arise (e.g. methane, how it is produced by the decay of large quantities of animal waste, atmospheric methane's role in trapping heat). Prompt students to consider different perspectives on the impact of the waste and how perspectives might differ from one another. If there are different solutions and some are more positive than others why are the more positive solutions not more widely used? Discuss reactions, and review questions on the DQB. Check and see if any questions have been answered and add any new questions.	Water quality, ground water, surface water. Air pollution, Ammonia, nitrous oxide, hydrogen sulphide, methane. Manure management, energy production, soil fertilizer etc. (as arises during student research).		Imagining: Compare and imagine different perspectives on the impact of animal waste.
4	Lesson periods 6 and 7	Show students the materials available for this lesson, explaining that the provided fertiliser contains phosphorus just like animal waste (and explain that phosphorus is a chemical element required for life that can also be toxic). Have students propose ways to investigate the impacts of animal waste on freshwater using the fertiliser. Record their ideas and support them with appropriate questions and suggestions (see the idea below, for example). Lead a discussion about the strengths, limitations, assumptions, and novelty of the ideas and deciding what criteria the class will use to select one idea. Once, the idea is selected students implement it, stopping regularly to reflect on what they are doing. The following is one idea you might follow, but the class may come up with other ideas to implement. Pairs or small groups fill three containers of water from a river or lake. Have students add no fertiliser to one and varying amounts to the other two (use garden fertiliser, or manure if more convenient). Students should carefully record which containers have which	Phosphorus. Conducting an investigation about the causes of algal blooms related to animal waste.	Imagining and Doing: Generate and implement ideas for how to investigate impacts of animal waste on freshwater in a personally novel manner.	Doing: Explain strengths and limitations of ideas for investigations according to different criteria.

		amounts of fertiliser. Ask students what they think will happen with the different containers. Check the containers daily, recording changes in appearance and smell and comparing across the classroom. Ask students what, if anything, this investigation reveals about how manure produced by high numbers of farmed animals would affect water quality and other plants and animals that live in the water. Show the class a picture of an algae bloom. Add questions, comments, and ideas to the DQB.			
5	Lesson period 7 and 8	In their previous small groups in which they focused on specific animals, students create models that follow nutrients from the food the animal eats through the waste it produces and follow the waste after disposal. Remind students that phosphorus and nitrogen come from animal waste and encourage algae blooms. As the algae decomposes oxygen in the water is used up, suffocating aquatic life. Their models need to show if their animal's waste can get into groundwater or above ground overflow. The models need to include the animal, the food it eats, the method of dealing with the waste, and the impact of that waste on the environment. Students should try to include ideas, for example, about waste disposal, that are personally novel or unusual (whilst still being meaningful). Students share their models with the rest of the class and discuss differences, strengths and limitations, and what might explain them. They discuss different criteria and perspectives that could be used to judge the strengths and limitations of the models	Physiology, digestion systems. Algae blooms and oxygen, and aquatic life. Groundwater and ground overflow. Modelling impacts of chemicals from animal waste on water and biological systems in water.	Doing: Producing a meaningful model of nutrient flow that is personally novel.	Doing: Explaining both strengths and limitations of models, according to different criteria and perspectives.
6	Lesson period 9	Lead a discussion about space. Have students consider the amount of space they need to be healthy and how much a pet needs. Help the class settle on a range for people and pets. In the small groups, have the students imagine and then create a space that they think would be big enough for a farm animal of the size they selected to be comfortable and healthy living in. In groups have the students find out the legal requirements for space available for their animals. They can also calculate how much space would be	Animal health, well-being and welfare. Applying mathematics to real-world problems.	Doing: Designing personally novel solutions based on criteria and constraints using non-traditional materials.	Imagining: Consider several perspectives on the space required by animals for health and well-being.

		needed for all the animals eaten in the community, if they all had a space similar to the design. Try it out, by remaining in the space with the small group, reading and writing, for 15 minutes. Imagine staying in it forever. Discuss, "where is all this space located for the animals that feed the community? What has been replaced to create enough space?" Ask, "Is my experience a good way to gauge being confined in a small space for animals? What other perspectives might be important to consider?" Discuss various answers and any assumptions involved in each. Students then reflect on their designs for spaces and make improvements. Add new questions to the DQB. Ask if any have been answered.		Reflecting: Reflect on steps taken to pose and solve a scientific problem.	
7	Lesson period 10	The class uses classroom materials to make a visual representation of the differences between the bio mass of livestock (cows and pigs) in the world and the bio mass of wild mammals currently and the prehistoric bio mass of wild animals. Encourage the students to come up with unique ways to represent these numbers and compare them, reflecting on their choices relative to possible alternatives. Ask: How much of the decline in wild mammals is due to the devotion of resources to farmed animals? What else might be a factor? Use this chart for a land use comparison.	Biomass of livestock versus wild animals. Natural resources. Constructing mathematical models.	Doing: Designing data visualizations in a personally novel manner.	Reflecting: Reflecting on the chosen approach to visual representation.
8	Lesson periods 11 and 12	Lead a discussion about how what people eat might impact the effects of farmed animals on the world and how this could be managed and mitigated. Ask students to brainstorm novel and unusual ideas for this (either in small groups or as a whole class). In discussion with students, identify one or two ideas to briefly explore further. For example, the class could return to the list of meals from step one and discuss whether those meals could be made without animal products. Encourage students to seek out recipes. Reflect on what was learned in the unit and the advantages and disadvantages of opening up more space for wild animals through dietary adjustments.	Connecting science ideas to everyday life and life's decisions.	Imagining: Generating novel and unusual techniques to mitigate the impacts of farmed animals. Reflecting: on the unit, on the novelty of proposed	Doing: Take and justify a personal position regarding the impact of farmed animals on the environment. Reflecting: Reflect on the chosen solution relative to possible alternatives.

	Finally, have students argue using evidence for and against the claim that reducing the amount of animals farmed would be beneficial to the environment.	solutions, and on what students learned.

Resources

Web and print

- Animals include but not limited to: pigs, cattle, egg laying hens, chickens
- For further study https://www.theguardian.com/environment/2018/may/21/human-race-just-001-of-all-life-but-has-destroyed-over-80-of-wild-mammals-study
- Algal Bloom
- Various classroom materials and recycled materials.

Other

- Access to research tools (phones, computers, etc), Cookbooks, cooking materials and food, scales
- Animal -free jelly candy
- Waste from different animals

Opportunities to adapt, extend, and enrich

- Have students locate resources in their community related to alternatives to animal agriculture.
- Visit a local restaurant that does not use animal products

Creativity and critical thinking rubric for science

Mapping of the different steps of the lesson plan against the OECD rubric to identify the creativity and/or critical thinking skills the different parts of the lesson aim to develop

	CREATIVITY Coming up with new ideas and solutions	Steps	CRITICAL THINKING Questioning and evaluating ideas and solutions	Steps
INQUIRING	Make connections to other scientific concepts or conceptual ideas in other disciplines	2	Identify and question assumptions and generally accepted ideas of a scientific explanation or approach to a problem	1, 2
IMAGINING	Generate and play with unusual and radical ideas when approaching or solving a scientific problem	3, 4, 8	Consider several perspectives on a scientific problem	3,6
DOING	Pose and propose how to solve a scientific problem in a personally novel way	4, 5, 6, 7	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.)	4, 5, 8
REFLECTING	Reflect on steps taken to pose and solve a scientific problem	6, 8	Reflect on the chosen scientific approach or solution relative to possible alternatives	7, 8