Enhancing Climate Change Education through Links to Agriculture

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ABSTRACT

Anthropogenic climate change is an urgent and pervasive challenge, yet it remains a polarizing subject. In the United States, studies have shown that rural communities tend to view climate change with less urgency than urban communities, which could delay action in response to the crisis. In rural areas that are highly dependent on agricultural production for their economies, linking climate change to agriculture could be key for improving climate change education. Here we propose a three-part framework that engages student and community knowledge of a locally relevant crop system to make local-global connections, connect the system to climate change, and analyze, critique, and design actionable solutions. The inclusion of lessons that link climate change effects to agriculture could play an important role in more effectively building understanding across cultural and regional divides.

Key Words: climate change; agriculture; rural communities; teaching strategies; climate education; framing.

Introduction

Anthropogenic climate change is a primary driver of global change (Intergovernmental Panel on Climate Change [IPCC], 2015), making it one of the most urgent and challenging problems we face. The scientific consensus is that human activities are the cause of climate change, given that levels of carbon dioxide (CO₂) and other greenhouse gases have been rapidly increasing in the atmosphere since the turn of the 20th century at a rate that parallels fossil fuel emissions and a rising average global temperature (IPCC, 2015). Extensive research points to the scope and severity of climate change effects (e.g., IPCC, 2021; IPCC, 2015; Dai, 2013; Hansen et al., 2010; Allen et al., 2010; Nicholls & Cazenave, 2010), so taking immediate action has been deemed essential (United Nations Environment Programme [UNEP], 2019).

The Paris Agreement of 2016, which is currently signed by 191 countries and the European Union, set a goal to take immediate action to limit the increase in global mean temperature to 2°C above preindustrial levels. According to the United Nations Environment Programme’s Emissions Gap Report 2019, adequate action has not yet been taken, and they suggest that global emissions must be cut 2.7% per year from 2020 to 2030 to keep warming under the target of 2°C (UNEP, 2019). Taking the kind of global action that is required to drastically cut carbon emissions will require widespread and urgent support, especially among countries with major economies (i.e., the greatest polluters), including the United States.

Despite overwhelming evidence for the effects of climate change, it remains a highly polarizing subject in the United States. There are clear demographic divides in climate change understanding and acceptance across socioeconomic, educational, regional, ideological, and political lines (Ballew et al., 2020; Bonnie et al., 2020; Hoffman, 2011; Zia & Todd, 2010). For example, a Pew research poll in 2020 found that while 88% of participants who identified as Democrats believed climate change is “a major threat to the nation,” those who identified as Republicans had a far less urgent view. Just 31% of Republicans called climate change a “major threat,” 45% said it was a “minor threat,” and 24% said it wasn’t a threat at all (Kennedy, 2020).

In addition to a political divide, there is an evident divide between urban and rural communities. For example, research suggests that while urban/suburban voters call climate change one of the top two most important environmental issues, rural voters consider issues that have more immediate impacts, such as protecting farmlands, to be a higher priority (Bonnie et al., 2020). Additionally, 54% of rural voters suggested it is important that the United States take action on climate change versus 69% of urban/suburban voters (Bonnie et al., 2020). This disparity in perception of climate change urgency, combined with the truly time-sensitive nature of policy action to curb global warming (UNEP, 2019), calls for increased
focus on improving climate change education strategies in rural agricultural communities.

How can we remedy this gap in climate change understanding and urgency? One solution can be found through adapting the framing of climate change education to regionally specific issues. Research suggests that when teaching about climate change, framing the discussion is crucial (e.g., Benjamin et al., 2017; Dickinson et al., 2013, Stevenson et al., 2018), and connecting climate change to local issues and actions is a useful strategy for building interest and urgency (e.g., Anderson, 2012). Because communities tend to prioritize issues that are most immediate (Bonnie et al., 2020), we see an opportunity to bridge the more abstract concept of climate change with more immediate priorities. In rural communities that rely heavily on agriculture for their livelihoods, culture, and economy, linking climate change to agriculture may help to improve accessibility, interest, and long-term engagement (Stevenson et al., 2018). Here, we provide a framework for the integration of lessons that emphasize the potential effects of climate change on agricultural systems, with the goal of targeting climate change education for rural agricultural communities.

○ What Is Effective Climate Change Education?

To promote effective teaching of climate change, first it is important to consider the goals of climate change education. If the ultimate goal is action, it is critical for students to develop a foundation of scientific knowledge, skills that they can use to leverage that knowledge into action in their communities, and the drive to do so. For example, the U.S. Global Change Research Program (2009) developed a set of seven Essential Principles of Climate Science Literacy that promotes understanding of the human influence on climate and the influence of climate on humans and society. According to these principles, climate literacy must include a personal connection between the learner and the science, where the learner understands their role in climate change and how climate change might affect their life. A similar sentiment is laid out in the United Nations Educational, Scientific and Cultural Organization’s (UNESCO’s) *Education for Sustainable Development Goals* for climate action. They call for learning objectives in the realms of cognitive, socioemotional, and behavioral learning so students cultivate the necessary tools to understand the science, connect the science to their activities, and take action to slow or reverse climate change and its impacts (UNESCO, 2017). The overarching goal of these objectives is to empower students to confront the issue of climate change.

In the United States, the development and adoption of the Next Generation Science Standards (NGSS) has been associated with inclusion of climate literacy education (National Research Council, 2012; Hestness, 2014). The adoption of NGSS in K–12 education provides opportunities for climate change education across elementary, middle, and high school science curricula that align with the seven Essential Principles of Climate Science Literacy (Busch & Osborne, 2013). Taking the step of implementing the NGSS goes a long way to increasing the quantity and quality of climate change education in U.S. classrooms, but the question of how best to approach this controversial and complicated subject with students, especially those from diverse socioeconomic backgrounds, still remains.

In recent years, research on environmental education has moved beyond consideration of whether climate change needs to be taught in schools toward how best to teach this complex issue effectively. For example, in a systematic review of literature on climate change education assessment, Monroe and colleagues (2017) identified key strategies that may improve effectiveness of educational interventions and activities geared toward the teaching of climate change. The authors identified two key themes to improved effectiveness: focusing on making climate change personally relevant and designing the activities in a way that is engaging to learners. They also identified strategies such as using deliberative discussion, interacting with scientists and the scientific process, addressing misconceptions, and designing projects that address climate change in their communities to further the learning process (Monroe et al., 2017). Additionally, Zumbo and colleagues (2021) provided evidence that reception to climate change education is not simply a matter of exposure to mechanistic knowledge about climate change. While their study showed that increased exposure to climate change knowledge increased receptivity, it also found that more conservative worldviews decreased receptivity. In developing effective climate change education strategies, considering complexities in student values and ideologies is critical to enhancing understanding and retention.

In this paper, we focus on development of educational strategies that address the effects that climate change could have on the daily lives and communities of students, as this is where we believe we can most effectively engage students in action-oriented climate change education. To achieve this goal within agricultural communities, we suggest the use of a locally relevant agricultural system or crop as a case study that can be explored in depth from its agroecology to its global supply chain. We propose a framework for high school students that includes three types of lessons that are needed for a successful case study (Figure 1): (1) lessons that bridge local and global systems and interests, (2) lessons that apply scientific knowledge about climate change effects to the case study system, and (3) lessons that provide the opportunity for students to learn about currently available solutions and to use their knowledge and creativity to design their own solutions. It is worth noting that while each of these types of lessons is key to the success of the case study, the case study does not have to be limited to only three lessons, as some practitioners may need to spend more time on certain aspects of the curriculum. We will explore each of these lessons in depth in the next sections.

**Figure 1.** The three types of lessons and their key components in the proposed framework to integrate local agricultural case studies into climate change education in rural agricultural communities.
Integrating Climate Change & Agriculture in the Classroom

The agricultural case study can be presented through three types of lessons that, taken as a whole, provide an integrated approach to understanding climate change impacts on the selected system. Here we provide an overview of each type of lesson in the framework.

1. Bridging Local & Global Systems

The first part of the recommended agricultural case study utilizes knowledge of the students in the classroom to put the crop system in local and global contexts. Ideally, the agricultural system chosen for these lessons is one that is familiar to the students so they can play an active contributing role in class discussions. This builds on the idea of a place-based approach to education (Semken, 2005; Semken & Freeman, 2008), which Roehrig and colleagues (2012) describe as “grounded in the notion that the students’ local environment and community are a primary resource for learning. Place-based education promotes learning that is rooted in the unique history, environment, and culture of a particular place.” Place-based approaches have been effective in both urban environments (Endreny, 2010) and rural environments (Gruenewald, 2003; Semken, 2005) because they engage students with their local environments to solve “real local” problems (Sobel, 2014). In rural agricultural communities in the United States, approaching climate change education from a place-based approach means rooting discussions in local culture, tradition, and values. Engaging students with locally relevant systems and by calling on their experience and knowledge to inform development of these lessons is key to this approach, as it activates emotions, attitudes, and motivations for the students and creates a feeling of ownership in the ultimate outcome of the lessons (Van der Hoeven Kraft et al., 2011).

The objective of this first type of lesson is to build on familiarity with the local crop system and ensure that there is adequate background information for the development of situational interest (Schraw et al., 2001). This goal can be achieved, for example, through discussion of the supply chain (see the sample plan for Lesson 1 in the Supplemental Material available with the online version of this article). Exploring the product’s supply chain with the students is a valuable tool to set the agricultural system in context, and it helps to bridge the students’ knowledge from the local to the global scale. Exploring the supply chain involves examining crop supply to answer questions such as these: Where is this crop grown? Who grows it? How much land is it grown on? What resources are needed to maximize crop production? Are there subsidies available for farmers who grow the crop, and what role do they play in sustainability of crop production? Once that foundation is developed, the discussion can expand to the rest of the supply chain to look at how the crop is processed, who buys the product, and who is impacted if crop production declines. Exploring the crop’s supply chain with students will create opportunities for reflecting on what might be the causes and consequences of a disrupted supply chain.

2. Connecting the System to Climate Change

The objective of the second type of lesson in this framework is to apply scientific knowledge about climate change effects to the case study system. Overall, these lessons should have three intertwined goals: to develop in students a more nuanced understanding of the agroecosystem, to review climate science and expected outcomes. Figure 2.

![Projected Mid-Century Temperature Changes in the Midwest](image)

![Soybean Production Map](image)

![Corn Production Map](image)

Figure 2. (A) Projected mid-century temperature changes for the Midwest states of Minnesota, Iowa, Missouri, Wisconsin, Indiana, Michigan, Illinois, and Ohio (Pryor et al., 2014); (B) soybean production map (USDA, n.d.); (C) corn production map (USDA, n.d.).
of climate change, and to predict ways in which climate change impacts could affect the case study agroecosystem.

Developing a more nuanced understanding of the agroecosystem will differ depending on the crop that is being studied. Agriculture in the United States is highly varied (U.S. Department of Agriculture [USDA], n.d.), and the challenges of different agricultural systems will differ by climate and context (Figure 2). For example, a focus on corn or soybean production will lead to quite different discussions than would a focus on orchard crops, livestock, or aquaculture. Whatever the system of interest, however, the lesson should focus on the requirements of that particular crop to be productive (including but not limited to specific temperatures; water requirements; nutrients; carbon dioxide; and pest, disease, and weed control). Though some of these requirements are met by the environment (e.g., temperatures, day length, CO₂, soils) and some are more reliant on active human intervention (e.g., nutrients; pest, disease, and weed control; and water availability), all rely directly or indirectly on climatic conditions. Exploring the direct and indirect impacts of climate on crop production will prepare the students to hypothesize impacts of a changing climate on those systems.

The next component of this lesson is to review foundational climate science to better identify climate change impacts. Since this case study is aimed for high school students, it is likely that in educational programs that strive to meet NGSS standards, climate science would have been introduced already in elementary and middle school curricula (National Research Council, 2012; Hestness, 2014; Busch & Osborne, 2013), so this section is provided simply as a review to prime students to develop hypotheses for the case study agroecosystem. However, in cases where foundational climate science may not have been adequately presented, it could be valuable to take time at this point to provide the background material in more detail.

At this point in the lesson, the students will be adequately familiar with the local and global context of the crop and requirements for crop productivity (via in-class discussions previously described). Students can then integrate this knowledge to start making predictions about how projected changes in temperature, precipitation, CO₂, and range shifts for pests and disease under climate change could affect the agricultural system.

3. Analyzing & Designing Solutions

The third lesson in this framework provides an opportunity for students to synthesize key concepts from the case study, analyze potential solutions, and, ultimately design their own actionable solutions to respond to climate change in their community. The goal is to encourage students to think critically about how farmers and others who are directly reliant on agricultural production can respond to climate change and how their actions, as students and citizens, could impact those outcomes (Monroe et al., 2017). This goal could be achieved through a discussion of how different groups within their local community have attempted to respond to climate change. Typically, responses to climate change fall into one of two categories: mitigation or adaptation. Mitigation efforts aim to reduce the effects of climate change, and adaptation efforts aim to cope with the effects that are unavoidable. For example, a farm might play a role in climate change mitigation by adopting strategies that increase their carbon sequestration or reduce their greenhouse gas emissions, and they could adapt to climate change by adopting climate-smart agriculture (CSA) practices, such as crop diversification (Altieri & Nicholls, 2017). One way to achieve the goal of this lesson is to base the discussion on recent and relevant scientific research from the case study system using the principles of inquiry-based education (Roehrig et al., 2012). Inquiry-based approaches involve engagement of students with scientific questions, development of knowledge that is based on evidence, extrapolation of explanations from that evidence, evaluation of alternative explanations, and justification of proposed explanations (National Research Council, 2012; Roehrig et al., 2012). With their background in the subject material at this point in the lessons, the students should be able to comprehend and actively critique current research, explore how they might improve climate change adaptation or mitigation strategies on farms, and develop ideas for how that research might be expanded or improved.

Alternatively, and possibly more successfully, the discussion could be based on the work of a local farmer or agricultural community leader who is actively involved in climate change adaptation or mitigation. In some agricultural extension approaches, for instance, extension agents first identify innovative farmers within a region who are applying novel techniques or practices and then bring other interested farmers to visit and discuss with the innovative farmer. They often find that farmers are more open to receiving new ideas from someone within their community than from an extension professional (Swanson & Rajalahti, 2010). Including the voice of an innovative local farmer or community leader in the learning process will provide students the opportunity to hear first hand how climate change is impacting farmers within the agricultural and cultural context of their community. Depending on the situation, a potentially valuable option would be to bring this farmer on board for curriculum development. If this approach is taken, the farmer’s story and experience can be featured heavily through the first two lessons and used as an extended example.

Whether examples from scientific research or local farming adaptations are featured, the final step is to have students consider how they can take action to protect these agricultural systems. The students can use their knowledge and experience to design implementable solutions for their communities, which will increase the recognition that climate change is a local, relevant, and urgent issue (Monroe et al., 2017).

Next Steps in Targeting Climate Change Education

Overall, the steps outlined in the framework above should help students in rural agricultural communities engage more directly with the issue of global climate change. In the Supplemental Material (with the online version of this article), we provide three sample lesson plans that demonstrate how we used this framework to create a three-lesson unit for a high school environmental science class. However, we recognize that it would also be possible to expand the material to spend more time on certain aspects of the curriculum over multiple lessons. For example, to adapt this curriculum to middle school classrooms that may not have had as much exposure to basic climate science, more time could be allocated to meeting the goals outlined for each lesson (e.g., spending two classes meeting the goals of each lesson instead of just one). This expansion would provide ample time to present necessary background information and review basic scientific information that is needed to understand the lesson. Regardless of how the framework is applied...
in practice, ensuring that the goals of each type of lesson covered in this paper (bridging local and global systems, connecting the system to climate change, and analyzing and designing solutions) are met will improve the effectiveness of this approach.

For students in rural agricultural communities, connecting the idea of climate change to local agricultural systems could help improve understanding of this critical issue. However, to get the full benefit of this approach, it is key to tailor the case study specifically to local cropping systems and student interests in specific classes. The USDA maps of growing regions for primary crop species (Figure 2) are good references for teachers to examine primary cropping systems in their area, although there are, obviously, many other crops grown in the United States. To achieve learning objectives, student interests, prior student understanding of climate change, and specific class goals should be considered when applying this framework.

This framework can be expanded beyond a local agricultural context to meet a broader set of curriculum goals. For example, if a curriculum goal is to learn about climate change effects on otherwise unfamiliar global ecosystems (e.g., tropical agroecosystems such as coffee or cacao for students in the upper Midwest United States), this framework could be used within the context of that agroecosystem to engage relevant local knowledge about agricultural systems in an otherwise distant issue. If the students have a baseline understanding and familiarity with agricultural systems, then applying that knowledge to other global agroecosystems could help to bring those systems, and the potential impacts of climate change on those systems, into context.

In sum, this paper provides a conceptual framework for engaging students in rural agricultural communities with the challenges of climate change. It also opens a path forward for research that explores the effectiveness of targeting rural communities with an agriculture-based approach to climate change education. With an urgent and polarizing issue like climate change, education is key to provoking action. As scientists, we must take action within our universities to discover new ways to engage students with this issue.

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