Next-Generation Perspectives on AI and Environmental Costs in Controlled Environment Agriculture (CEA): A High School Survey Study

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Abstract

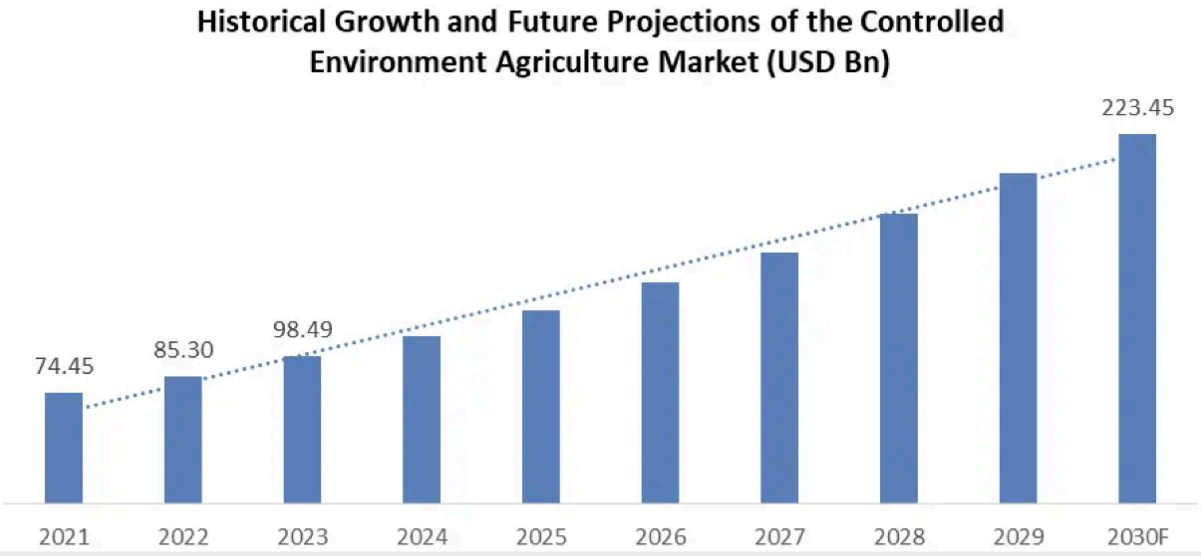
As climate challenges intensify and the global population continues to rise, controlled environment agriculture (CEA) offers a promising alternative emerging in today's markets. However, several factors have limited the rapid adoption of CEA, with public acceptance, particularly among younger generations, posing a potential barrier. This study examines high school students' awareness and perceptions of CEA, with a focus on concerns related to artificial intelligence (AI) and environmental impacts. Two surveys were conducted among 122 students, revealing that while 81.2% had never heard of CEA, many were initially open to the concept. Yet exposure to information about potential drawbacks led to a 74% increase in opposition. The primary concerns included job displacement, food safety, and waste generation. Despite these worries, 94.1% of students indicated they would consider supporting CEA if specific solutions, such as maintaining human oversight, ensuring transparency, and prioritizing sustainable practices, were implemented. These findings suggest that support for CEA is achievable by proactively addressing key concerns to build trust among future consumers. Currently, there is a need for further studies to not only identify possible obstacles like the teen perceptions indicated in this study, but also how they can be addressed before the industry grows and faces consumer opposition.

Introduction

Controlled environment agriculture (CEA) encompasses a range of high-tech growing methods, including greenhouses, vertical farms, and hydroponic systems, all of which precisely regulate variables including temperature, light, water, nutrients, and carbon dioxide within enclosed environments (Cowan et al., 2022). And, despite obstacles and failures (Gordon-Smith, 2023), CEA systems have been increasingly implemented worldwide. This trend is documented by the Global CEA Census Report, with 84% of respondents reporting plans to expand production areas within the next 12 to 24 months (Meister Media Worldwide & Agritecture Consulting, 2025). This momentum is expected to continue,

with projections estimating that the global CEA market will maintain a compound annual growth rate of approximately 12.42% between 2025 and 2032, as shown in Figure 1 (Maximize Market Research, 2025).

Figure 1



Adapted from Maximize Market Research (2025)

CEA offers potential solutions to many limitations faced by conventional agriculture. Traditional farming practices often cause environmental degradation due to land overuse; for example, excessive tilling and monoculture cultivation, though efficient in the short term, can lead to soil erosion, desertification, and biodiversity loss. Moreover, the widespread use of synthetic fertilizers has been linked to the eutrophication of water bodies, and pesticides to the development of resistance in pest populations (Cunningham, 2017). Transitioning to controlled and efficient systems like CEA can be critical in reducing agriculture's environmental footprint while maintaining food security in a changing climate. CEA promises significant reductions in land and water use, lower fertilizer requirements, and increased local food production with higher yields.

To support the broader adoption of these technologies, it is crucial to explore the barriers related to consumer perception. Inspired by the public resistance that once slowed the acceptance of

genetically modified organisms (GMOs), this study investigates how high school students perceive CEA, which currently lacks research. Understanding students' attitudes could inform public engagement strategies for next-generation food systems and ultimately reduce future costs associated with rebuilding public trust.

The purpose of this research is to examine high school students' baseline awareness, concerns, and openness toward CEA, focusing specifically on artificial intelligence and environmental issues such as e-waste and landfill contributions. High school students were chosen because they represent the next generation of consumers, voters, decision makers, and agricultural workforce members. Their current perceptions could shape future demand and influence policy, helping to determine whether CEA gains or loses public trust over time.

Methods

This study employed a descriptive survey design to explore awareness, attitudes, and opinion changes among high school students regarding CEA. Two Google Form surveys were used.

Participants and Sampling

Participants were recruited from Calabasas High School using convenience sampling. Survey I was distributed via a shared link to two classes, producing 37 responses. Survey II was administered in-person to six classes after a short oral introduction, producing 85 valid responses (two excluded for missing consent). All participants were between 14 and 18 years old, with no other personal identifiers collected. While convenience sampling limits generalizability, it was chosen for this study to identify potential trends that could inform larger-scale research.

Survey Instrument Development and Content Validity

Survey questions were adapted from prior research on sustainability education and perception research (Benke & Tomkins, 2017; Hasimuna et al., 2022; Rotz et al., 2019). CEA and key concerns (Energy & Resource Use, Automation & AI, Waste Concerns, Community Impact) were defined within the survey to ensure a consistent understanding among participants.

Survey-Research Question Alignment

Survey I:

Research Question	Survey Questions
RQ1: What is students' baseline understanding of CEA?	Q2: "Do you know how most of your food is grown?" Q3: "Have you heard of Controlled Environment Agriculture (CEA)?"
RQ2: What are students' attitudes toward CEA and related factors?	Q1: "Do you care about where your produce is grown?" Q4: "Would you buy food grown in an indoor farming facility (CEA) instead of traditional farms?" Q7: "Would you support having a CEA facility in your community?"
RQ3: How does information shape perceptions?	Q5: "Has your opinion on CEA changed after learning about these drawbacks?" Q6: "Which factor had the biggest impact on your opinion?" Q8: "What solutions or changes would make you more supportive of CEA?"

Survey II:

Research Question	Survey Questions
RQ1: What is students' baseline understanding of CEA?	Q2: "Do you know how most of your food is grown?" Q3: "Have you heard of Controlled Environment Agriculture (CEA)?"

RQ2: What are students' attitudes toward CEA?	Q1: "Do you care about where your produce is grown?" Q4: "Would you buy food grown in an indoor farming facility (CEA) instead of traditional farms?"
RQ3: What are students' attitudes toward AI?	Q5: "How do you feel about the use of AI and automation in food production?" Q6: "What are your biggest concerns related to AI in food production?"
RQ4: What are students' attitudes toward waste issues?	Q7: "How do you feel about the non-organic waste generated by CEA?" Q8: "What are your biggest concerns related to non-organic waste in food production using CEA?"
RQ5: How do various solutions affect perceptions?	Q9: "Which of the following would make you more supportive of CEA?" Q10: "Would you now consider supporting a CEA facility in your community if it addressed your AI/waste concerns?" Q11: "What would make you feel more comfortable with indoor farming (CEA)?"

Data Analysis

Close-ended responses were analyzed using descriptive statistics (counts, percentages). Open-ended responses were used to identify recurring or new ideas and concerns.

Both surveys included an informational section explaining the CEA process, its benefits, and its drawbacks. Participants answered multiple-choice and checkbox questions, along with one short-response question for additional comments. These questions assessed students' opinions, knowledge, concerns, and openness to CEA under different conditions (e.g., if recyclable materials were used, if AI systems were transparent, or if humans worked alongside machines).

To determine overall support or opposition to CEA, responses to two key questions in Survey I were analyzed:

- "Would you buy food grown in an indoor farming facility (CEA) instead of traditional farms?"

- "Has your opinion on CEA changed after learning about these drawbacks?"

Participants were categorized as against CEA if they answered "no" to both questions, indicating stable disinterest, or if they answered "yes" to the first and "yes" to the second, indicating that they initially supported CEA but changed their mind after learning about the drawbacks. Participants were categorized as supportive of CEA if they answered "yes" to the first question and "no" to the second, showing consistent support, or if they answered "no" to the first question and "yes" to the second, suggesting they shifted from opposition to support after learning more.

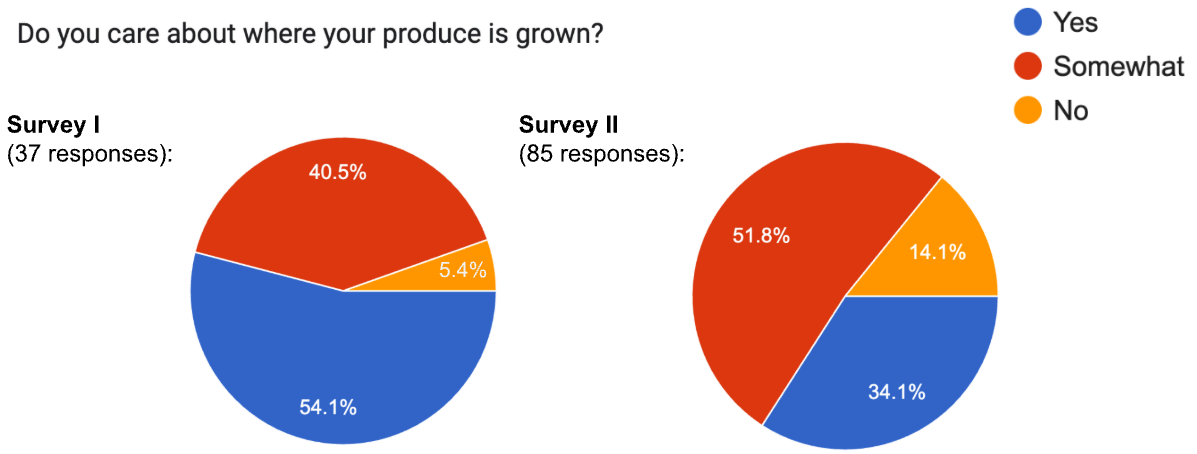
This approach enabled the identification of common concerns and analysis of shifts in perception after participants were exposed to additional context and potential solutions.

Results

The following graphs represent responses from the surveys conducted. Each graph is labeled with the corresponding question from the questionnaire and shows how participants answered. Between Surveys I and II, four questions were repeated to allow direct comparison and ensure results were reflective of the broader population's perspective.

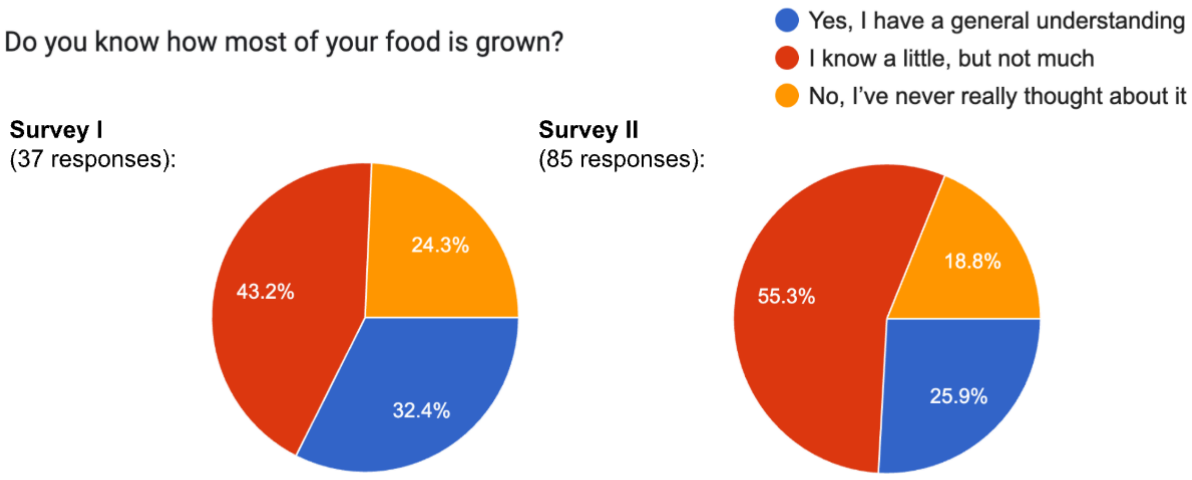
Students were asked whether they care about where their produce is grown. The majority (85.9%-94.6%) of students felt that they had a general understanding of where their produce is grown.

Figure 2



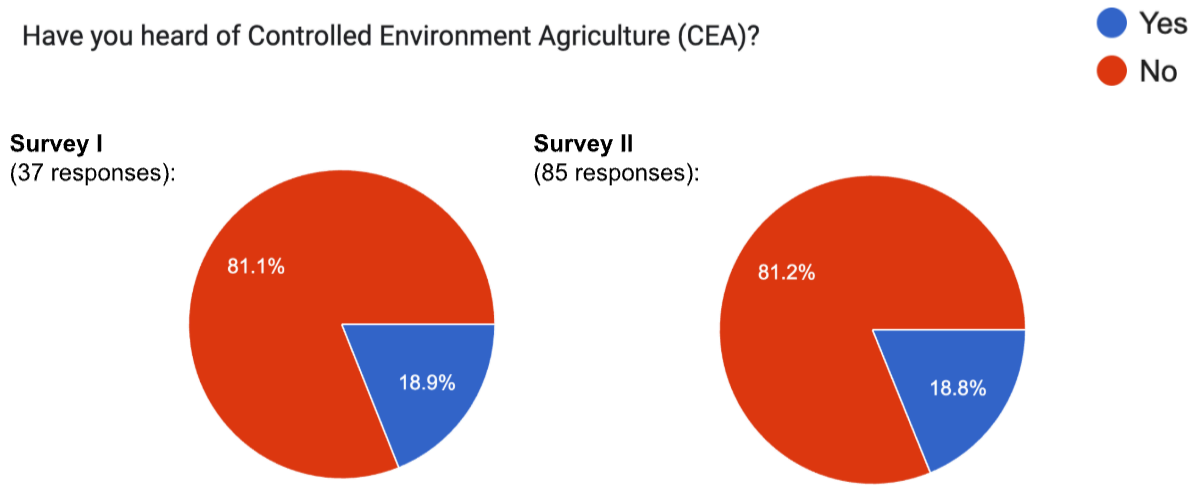
Students also reported on their level of knowledge about how most of their food is produced.

Figure 3



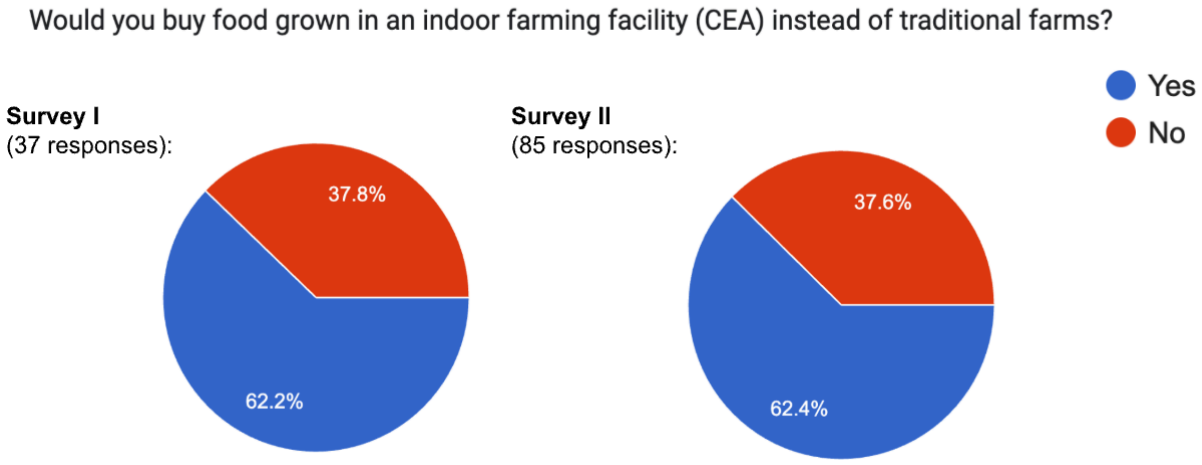
Only a small percentage of students in both surveys had previously heard of CEA.

Figure 4



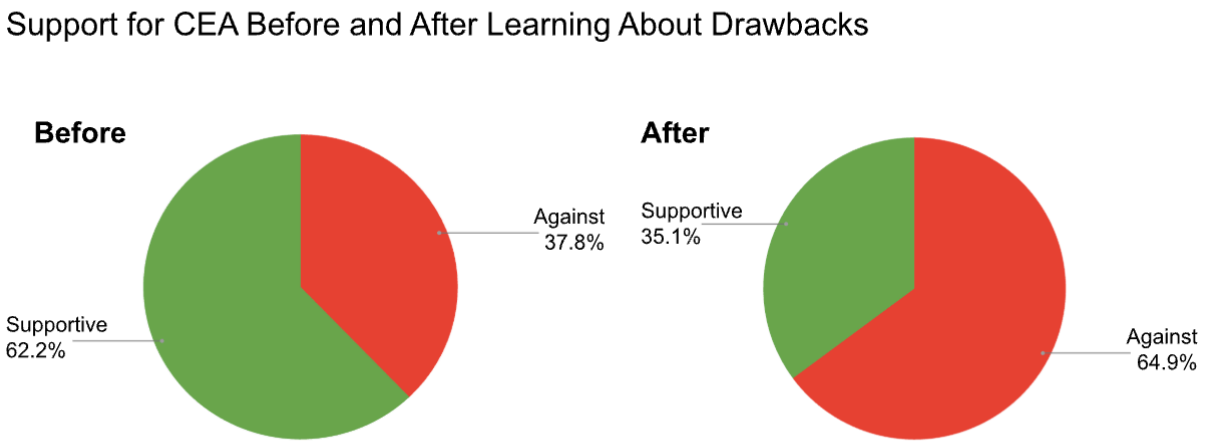
When asked if they would consider buying food grown in an indoor facility instead of traditional farms, responses were similar across both surveys.

Figure 5



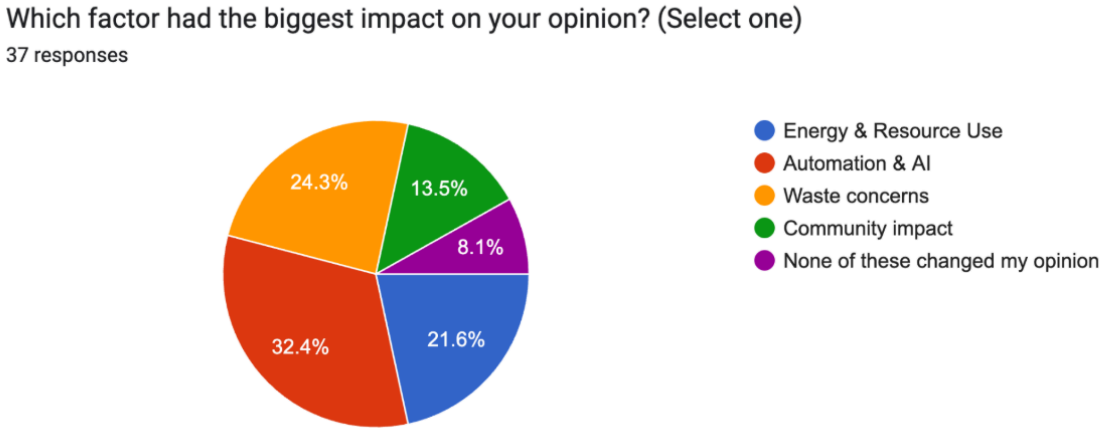
After being exposed to the concept of CEA and its potential drawbacks in Survey I, the number of students opposed to CEA increased by 74% compared to earlier opinions.

Figure 6



The drawbacks that had the biggest impact on their perceptions were identified as automation and AI, as well as concerns about waste.

Figure 7



In Survey II, which focused on these two top issues, the most significant specific worries included (1) loss of jobs (74.1%) and food quality or safety (68.2%) for AI, and (2) toxic waste from electronics (60.0%) and too much landfill waste (55.3%) for waste concerns.

Figure 8

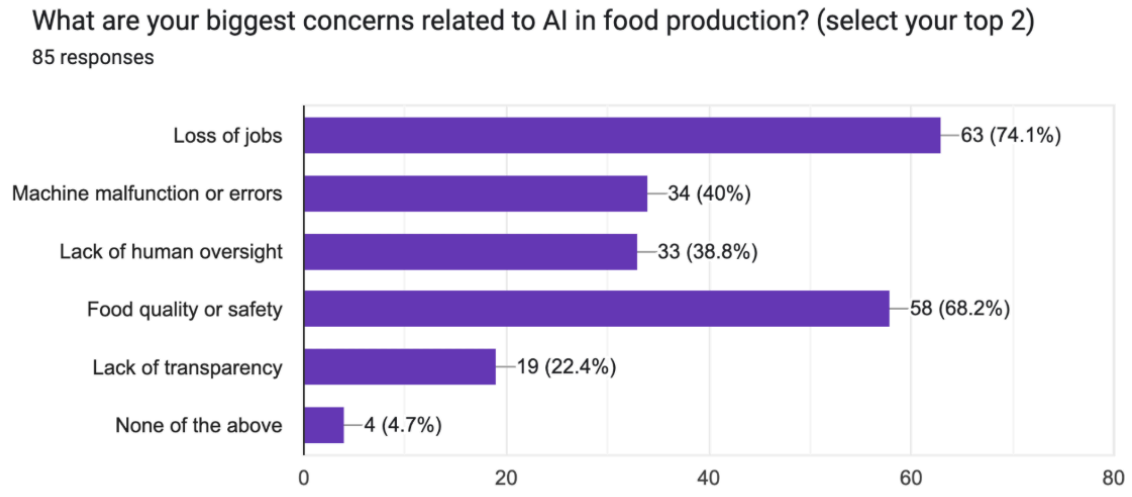
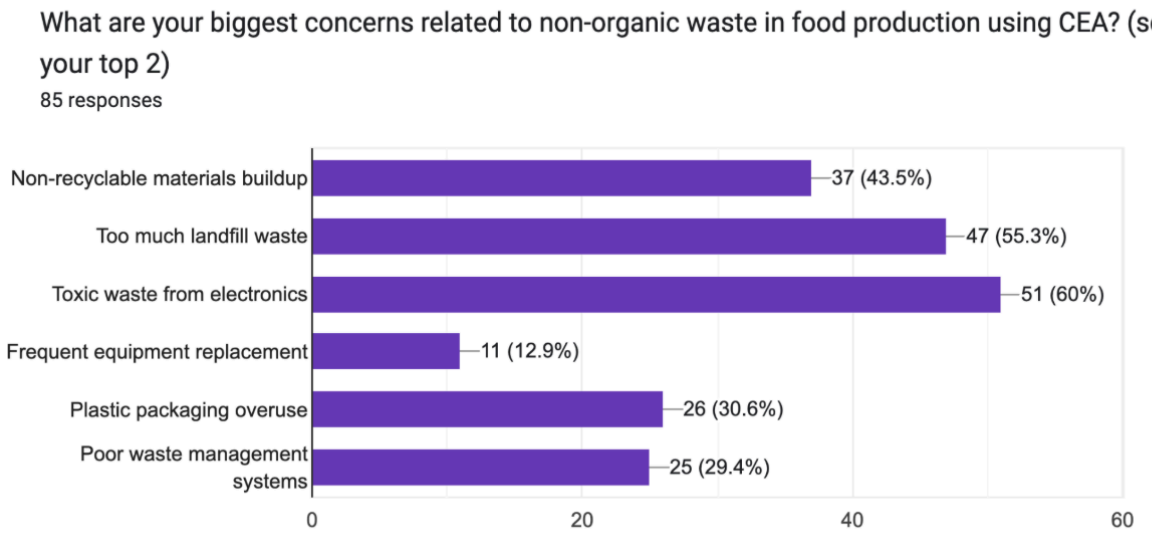
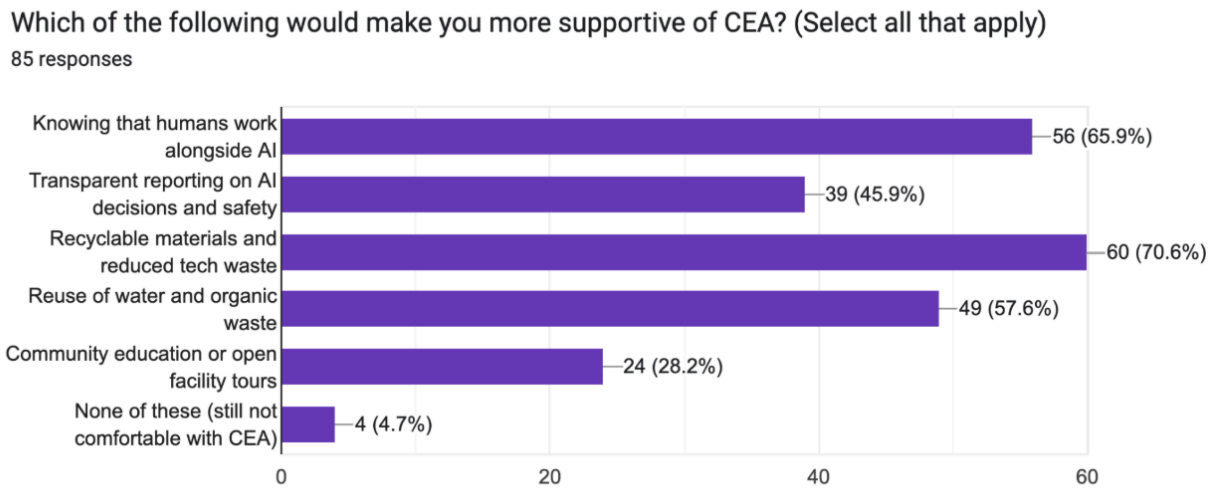


Figure 9



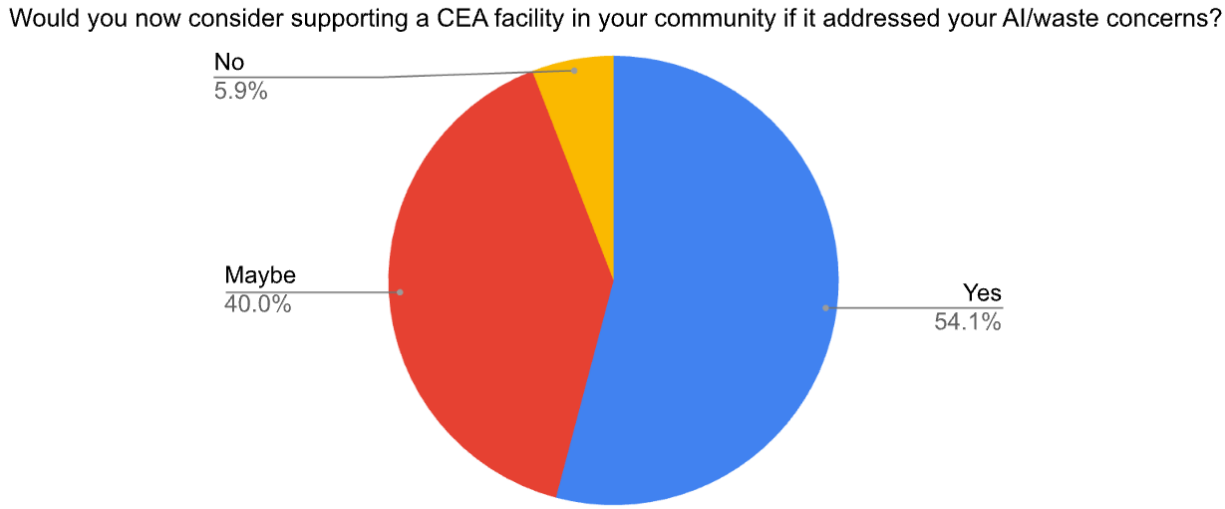
Participants then selected potential solutions that could increase support for CEA: 70.6% preferred the use of recyclable materials to reduce waste, and 65.9% wanted humans to work alongside AI in the growing process.

Figure 10



If these solutions were implemented, 94.1% of participants expressed that they would be somewhat or fully open to supporting a CEA facility in their community.

Figure 11



Discussion

Historically, the use of technology in food production has been controversial. Genetically modified organisms (GMOs), for instance, have the potential to address food insecurity but have often faced public resistance. Analysis of two million social media posts found that 32% of posts related to GMOs carried negative sentiments, and 71% reflected unpleasant emotions (Sohi et al., 2023). Such perceptions have hindered the progress of the GMO industry in regions like Europe. Similarly, food grown through CEA has been perceived by some consumers as "unnatural" (Marris, 2001). Both GMOs and CEA involve technological interventions in food production, creating potential for comparable challenges if public concerns remain unaddressed. The rapid spread of information and misinformation through social media can amplify challenges; across 19 countries, 84% of respondents agreed that “technological connectivity has made people easier to manipulate with false information and rumors” (Wike et al., 2022). Content spread through social media platforms could generate similar shifts, influencing large audiences in a short period.

Consistent results from both surveys showed that student awareness of CEA was relatively low, with only 18.8%-18.9% reporting familiarity (Figure 4). Despite this, initial willingness to buy food from indoor farms was relatively high (62.2%-62.4%), indicating openness to innovation even with limited prior knowledge (Figure 5). However, exposure to technically accurate but out-of-context information about potential drawbacks led to a substantial shift in attitudes: the number of students opposed to CEA increased by 74% compared to initial responses (Figure 6). This pattern, though not statistically confirmed, aligns with prior research showing that public opinion on emerging technologies can change rapidly. After only a few sentences of additional information, nearly twice as many participants expressed opposition to CEA, demonstrating its current susceptibility to social media. To counteract this, it is important for CEA companies to provide accurate communication by acknowledging trade-offs while also explaining benefits and solutions in order to prevent misinformation and maintain consumer trust.

Regarding specific concerns, only 8.1% of participants reported that none of the listed drawbacks changed their views, indicating that 91.9% felt discomfort about certain aspects of CEA (Figure 7). Addressing these concerns is essential for building broader support and preventing the development of opposition movements that could further influence public sentiment or policy. To explore measures that might shift opinions, participants were shown various solutions related to each issue and asked which would make them the most comfortable with CEA. Only 4.7% of participants indicated that none of the proposed changes would alter their stance (Figure 10). Overall, 94.1% were open to supporting a CEA facility if their key concerns were addressed, with 54.1% expressing definite support under those conditions (Figure 11). Tailoring solutions to public priorities could help transform skepticism into community engagement, fostering opportunities for local businesses.

The open-ended responses provided further insights. Many students were willing to support CEA under certain conditions, but others rejected the concept entirely, citing beliefs that it violates natural order because “robots should not grow our food.” Cultural and emotional factors played a role in shaping attitudes toward food production systems, which technological innovation alone cannot resolve. One student expressed a preference for traditional agriculture, describing enjoyment in visiting farmers’ markets to choose “FRESH produce that was grown from the ground, not by a robot” (Respondent 53).

Although support for CEA among students is conditional, broader acceptance seems achievable if issues such as job displacement, waste management, and openness in operations are addressed directly. Future education initiatives and community outreach should offer balanced information covering both the advantages and limitations of indoor farming. Transparent communication about trade-offs is crucial for avoiding perceptions of misleading claims or overpromising. Building public trust alongside technological development requires attention not only to technical progress but also to public values and expectations around food production. Such efforts may help bridge the gap between technological innovation and public trust.

Limitations

This study provides insights into high school students' perceptions of CEA, but it has limitations. The sample was limited to students from a single high school, which may not represent broader demographic or cultural perspectives. The survey constrained response depth, potentially overlooking nuanced opinions or factors influencing attitudes. Additionally, some participants might have provided socially desirable responses rather than expressing genuine views. Future research should include a larger, more diverse sample and use mixed methods to gain deeper insights into worldwide public perceptions of CEA.

Conclusion

This study explored high school students' perceptions of controlled environment agriculture (CEA), particularly in relation to artificial intelligence and environmental concerns. The results suggest that while students were initially open to the industry, they expressed skepticism after exposure to drawbacks. However, through further analysis, this skepticism can be relieved through a variety of solutions: increasing the use of recyclable materials, reusing organic waste, and including human oversight of AI. By implementing these efforts into business plans, 94.1% of students expressed that they would support industry efforts.

As CEA continues to expand, addressing misconceptions and clearly communicating trade-offs will be essential to gaining public trust. Future research could explore how different messaging strategies or types of evidence potentially impact perceptions across broader and more diverse populations. At the Autonomy Research Center for STEAHM* (ARCS) at California State University, Northridge, students have the ability to conduct further research efforts through various projects, such as FOODI: Facilitating Overcoming Obstacles to the Development and Integration of Modern Technologies for Controlled Environment Agriculture (CEA), Astro Cultivators: Autonomous Growth System for Space Farming, and

more. Ultimately, fostering informed support among the next generation of consumers and policymakers may be critical to the successful adoption of innovative food production systems.

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*__S__cience, __T__echnology + Engineering, __E__ntrepreneurship + Business, __A__rts, __H__umanities, and __M__athematics

References

Benke, K., & Tomkins, B. (2017, November 20). *Future food-production systems: vertical farming and controlled-environment agriculture*. Taylor & Francis. https://www.tandfonline.com/doi/full/10.1080/15487733.2017.1394054

Controlled Environment Agriculture Market: Growing Demand for Year-Round Crop Production – Industry Analysis and Forecast (2025-2032) Trends, Statistics and Segmentation Analysis. (2025, April). Maximize Market Research. Retrieved June 26, 2025, from https://www.maximizemarketresearch.com/market-report/controlled-environment-agriculture-market/147449/

Cunningham, W. P., & Cunningham, M. A. (2017). *Environmental Science*. McGraw-Hill Education.

Funk, C., & Kennedy, B. (2016, December 1). *3. Public opinion about genetically modified foods and trust in scientists connected with these foods*. Pew Research Center. https://www.pewresearch.org/internet/2016/12/01/public-opinion-about-genetically-modified-foods-and-trust-in-scientists-connected-with-these-foods/

Gordon-Smith, Henry. “Stories of the Year: What Does AeroFarms’ Bankruptcy Signal for CEA’s Future?” *The Food Institute*, 26 Dec. 2023, foodinstitute.com/focus/what-does-aerofarms-bankruptcy-signal-for-ceas-future/.

Hasimuna, O. J., Musuka, G., Munganga, B. P., & Phiri, J. (2022, June 14). *CEA Systems: the Means to Achieve Future Food Security and Environmental Sustainability?* Frontiers. https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2022.891256/full#B40

Marris C. (2001). Public views on GMOs: deconstructing the myths. Stakeholders in the GMO debate often describe public opinion as irrational. But do they really understand the public?. *EMBO reports*, *2*(7), 545–548. https://doi.org/10.1093/embo-reports/kve142

Meister Media Worldwide & Agritecture Consulting. (2025). *2024 Global CEA Census Report*. Retrieved from https://www.ceagworld.com/census/

Rotz, S., Gravely, E., Ian Mosby, Duncan, E., Elizabeth Finnis, & Horgan, M. (2019, May). *Automated pastures and the digital divide: How agricultural technologies are shaping labour and rural communities*. ScienceDirect. https://www.sciencedirect.com/science/article/pii/S0743016718307769

Sohi, M., Pitesky, M., & Gendreau, J. (2023). Analyzing public sentiment toward GMOs via social media between 2019-2021. *GM crops & food*, *14*(1), 1–9. https://doi.org/10.1080/21645698.2023.2190294

Wike, R., Silver, L., Fetterolf, J., Huang, C., Austin, S., Clancy, L., & Gubbala, S. (2022, December 6). *2. Views of social media and its impacts on society*. Pew Research Center. Retrieved July 1, 2025, from https://www.pewresearch.org/global/2022/12/06/views-of-social-media-and-its-impacts-on-society-in-advanced-economies-2022/

Raw survey responses are available at:

1. https://docs.google.com/spreadsheets/d/10cG9b0CAybP7SIGR7gfpUHiY9Um29fbvGngZGD8BDCc/edit?usp=sharing
2. https://docs.google.com/spreadsheets/d/1gqpKFW8x1LIFvUTMjWBd9fu8AlSBFYRWkdiwQ5XDrec/edit?usp=sharing