Controlled Environment Agriculture: A Case in Urban Agricultural Transformation

Abigail Boyd, Ph.D., Joan Lunney, Ph.D., Yaguang Luo, Ph.D.

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Shaping the Future of Science

Background

Controlled environment agriculture, or CEA, has emerged as a novel approach to food production. CEA can refer to a number of intensive horticultural techniques in which one or more variables is controlled, such as temperature, light, or humidity. Generally, it refers to growing crops in an enclosed environment, and operations can range in complexity from a simple greenhouse or hoop house to a fully automated vertical farm or "plant factory" (fig. 1).

Figure 1. Examples of a simple hoop house (A), smart greenhouse (B), vertical farm (C), and large-scale plant factory (D)

In the past several years, the CEA industry has seen rapid growth and increased attention due to its potential to help address complex agricultural challenges, such as climate change, diminishing land and water resources, and feeding a growing population. CEA operations offer many benefits, including minimized land and water use and the capacity to produce fresh food year-round, regardless of environmental conditions.

Convergence and CEA

Across food and agricultural research areas, the need for transdisciplinary approaches is amplified by the complex challenges facing the industry. Examples of disciplines employed in CEA research include:

- Chemistry
- Horticulture
- Economics
- Microbiology
- Engineering
- Extension & Outreach
- Food & Nutrition Sciences
- Plant Physiology

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September 19, 2023

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Annotated Bibliography
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Transforming Urban Agriculture

Adoption of CEA in urban areas is a promising approach to the transformation of local food systems. Urban areas have large populations and little arable land. Introducing CEA operations to these areas can help to provide fresh, nutritious food in close proximity to where it will be consumed, while utilizing minimal space and resources. However, there are many unique obstacles to building up a CEA operation for sustained success. Listed in this panel are examples of current challenges facing the CEA industry and opportunities for future growth.

Challenges

- Startup costs
- Energy usage
- Research gaps

After a period of prolonged growth, the CEA industry has faced significant adversity in the past year. Numerous companies struggled to scale sustainably, illuminating existing gaps in CEA research. Major challenges include startup costs and energy usage of highly automated systems, especially in CEA operations that rely solely on artificial light. Companies cannot afford to simultaneously address these issues and produce enough quality product to turn a profit. There is a need for trans-disciplinary research to improve energy efficiency and productivity and fill these innovation gaps.

Opportunities

- Enhance urban nutrition security via localized food production
- Minimize environmental impact of agriculture; reduce distribution cost
- Create new jobs and economic growth opportunities
- Incorporate animal agriculture and closed-loop systems
- Community engagement, education, and on-site demonstrations

Despite recent challenges in the CEA industry, it is still considered a key component of the future of our food system. CEA presents the opportunity to simultaneously minimize natural resource consumption, reduce waste, and increase the local availability of fresh food. In the long term, it may also contribute to local economies by providing jobs and educational opportunities. CEA has the potential to promote resiliency and equity in urban food systems. However, the industry needs the support of innovative, cross-cutting government research to help close existing industry gaps.

Cross-Agency Federal Research → Sustained Industry Success

Collaboration Vision

This panel summarizes different areas of expertise, resources, and programming across the Federal Government that are most relevant to CEA. This information is not intended to be comprehensive, rather it provides a conceptual framework for building stronger cross-agency research mechanisms.

Federal CEA Research

USDA
- **Expertise:** horticulture, plant physiology, biology, nutrition, food science, animal science, pathogen and disease responses, food safety
- **Resources**: ARS, ERS, NIFA, Climate Hubs, OUAIP, AgARDA

NASA
- **Expertise:** engineering, life sciences, innovation, tech transfer, remote sensing
- **Resources**: NASA Technology Transfer Program, STEM Engagement programs and funding

DOE
- **Expertise:** energy efficiency, renewable power, policy and analysis, decarbonization
- **Resources:** EERE, CEA Accelerator, funding and technical expertise, ARPA-E

FDA
- **Expertise:** food safety, nutrition, policy, extension and outreach
- **Resources:** regulatory and safety information, notices of outbreaks, investigations, reports, recommendations

NIH
- **Expertise:** biomedical science, nutrition, environmental health sciences, extension and outreach
- **Resources:** grants and funding, health and nutrition information, NIH Intramural Research Program, ARPA-H

Figure 2. Summary of urban CEA-related expertise, resources, and programming across the United States Government

Conclusion

Urban CEA is a timely example of an industry in need of multi-agency research investment. Our aim is to improve upon existing collaborations and identify new pathways to transformation in agricultural research. . Harmonizing Federal resources into a "whole-of-government" approach should be a priority to advance urban CEA.

Acknowledgements

This project is supported in part by an appointment to the Research Participation Program at the Agricultural Research Service, United States Department of Agriculture, administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the U.S. Department of Energy and ARS.