



THE UNIVERSITY OF ARIZONA
BIOSYSTEMS ENGINEERING

Controlled Environment Agriculture Center

Controlled Environment Agriculture

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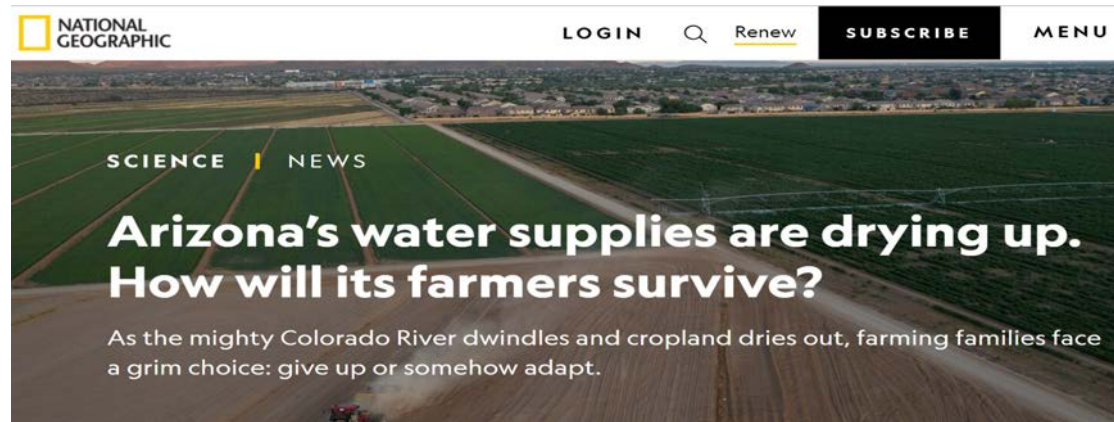
As a hotter, drier climate grips the Colorado River, water risks grow across the Southwest

Ian James Arizona Republic

Published 6:34 a.m. MT Apr. 23, 2021



“What really is starting to emerge is this really long pattern, that we're in a megadrought in a lot of the western U.S.,” said Laura Condon, an assistant professor of hydrology and atmospheric sciences at the University of Arizona. **“It's kind of like a cumulative impact, that we've just been getting hotter and drier and hotter and drier.”**



Arizona's \$23 billion agriculture industry is facing critical climate change-induced threat, with 90% of our state experiencing “exceptional drought” during much of the last two decades. **Arizona is faced a 20% reduction in Colorado River water by 2022, impacting our agricultural industries which account for nearly 70% of all water usage.**



“There is more demand for Colorado River than the river is producing. Lake Mead about full in 2000, now it is only 1/3 full. Consumption without depositing back into savings, there is a chance the hydropower production will be jeopardized and the flows even downstream of the dam will be jeopardized.” Sharon Megdal, UArizona.

Aging workforce and need for younger and more skilled workforce needed to shape/support the future of Arizona's agriculture.

- Arizona Ag industry is also facing a critical current and future workforce shortage and the ***average age of a principal farm operator in Arizona is approximately 61 years old.***
- ***A younger and more skilled workforce is needed to shape and support the future of Arizona's agriculture.***
- Adoption to Controlled Environment Agriculture (CEA) as a far more efficient way to produce more food with fewer resources largely independent of external climate conditions is available and is considered.
- However, ***CEA is technology intensive and requires specialized training and advanced knowledge of plant biology, technology, and engineering.***



What is Controlled Environment Agriculture (CEA)

An innovative method of growing plants with integration of engineering and plant sciences, and environmental controls that creates optimized aerial and root zone environments, focusing on production benefits such as:

- *predictable* crop timing and yield,
- *consistently* available produce with high quantity and quality,
- *high resource use efficiency,*
- *no pesticide use*
- *and, minimum environmental impact*



Why Controlled Environment Agriculture

- Production Quality/Consistency
- Water use efficiency
- Nutrient capture & recycling
- Energy efficiency
- IPM for Biological Control
- Transportable System
- Urban/Suburban Green Space
- Functional on poor lands
- Complements field production
- Captures Imagination of young generation
- Transportation Energy Reduced
- Community Supported Agriculture
- Supports Local Markets

20x yields in greenhouse compared to field

15-20x more Water Use Efficient (WUE) in greenhouse than field production, and **90-95x more WUE** vertical farm than field.

20-50x space efficient in greenhouse, e.g. lettuce, vs. field production

Global CEA market has been growing at an unprecedented rate, with the market **projected to grow from \$74.5 billion in 2020 to \$172.1 billion by 2025**, registering a compound annual growth rate **(CAGR) of 18.7% between 2020 and 2025.**



Technology Levels for Controlled Environment Agriculture



Urban Ag

Greenhouse technologies and industry are mature and advancing.



Wholesum, AZ



Gotham Greens, CA/NY/IL/CO



AppHarvest, KY



Tanimura & Antle, TN



Winset Farms, CA



Bright Farms, PA/OH/NC/VA/IL

Vertical Farming is fast evolving.



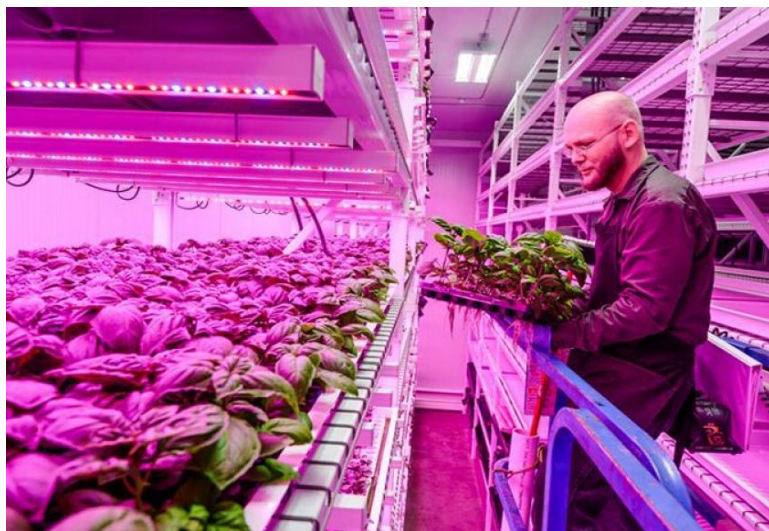
AeroFarms, NY, USA



Plenty, San Francisco & Los Angeles, CA, USA



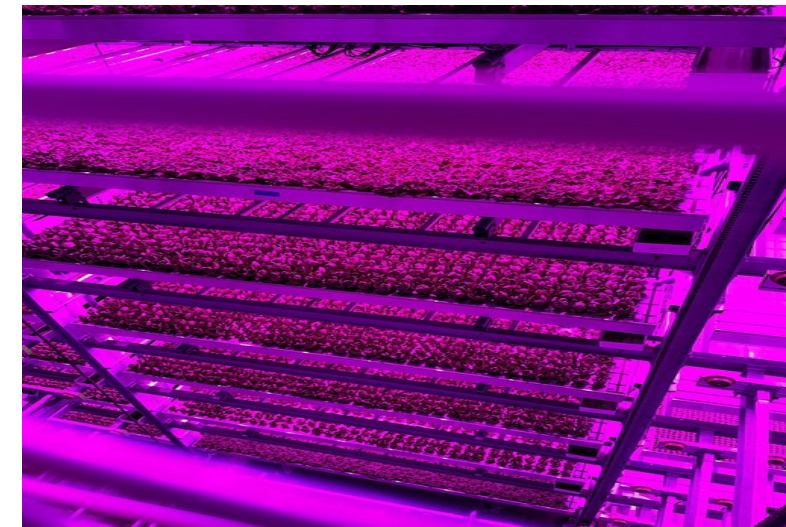
Bowery, NY, USA



Greensense Farms, IN, USA

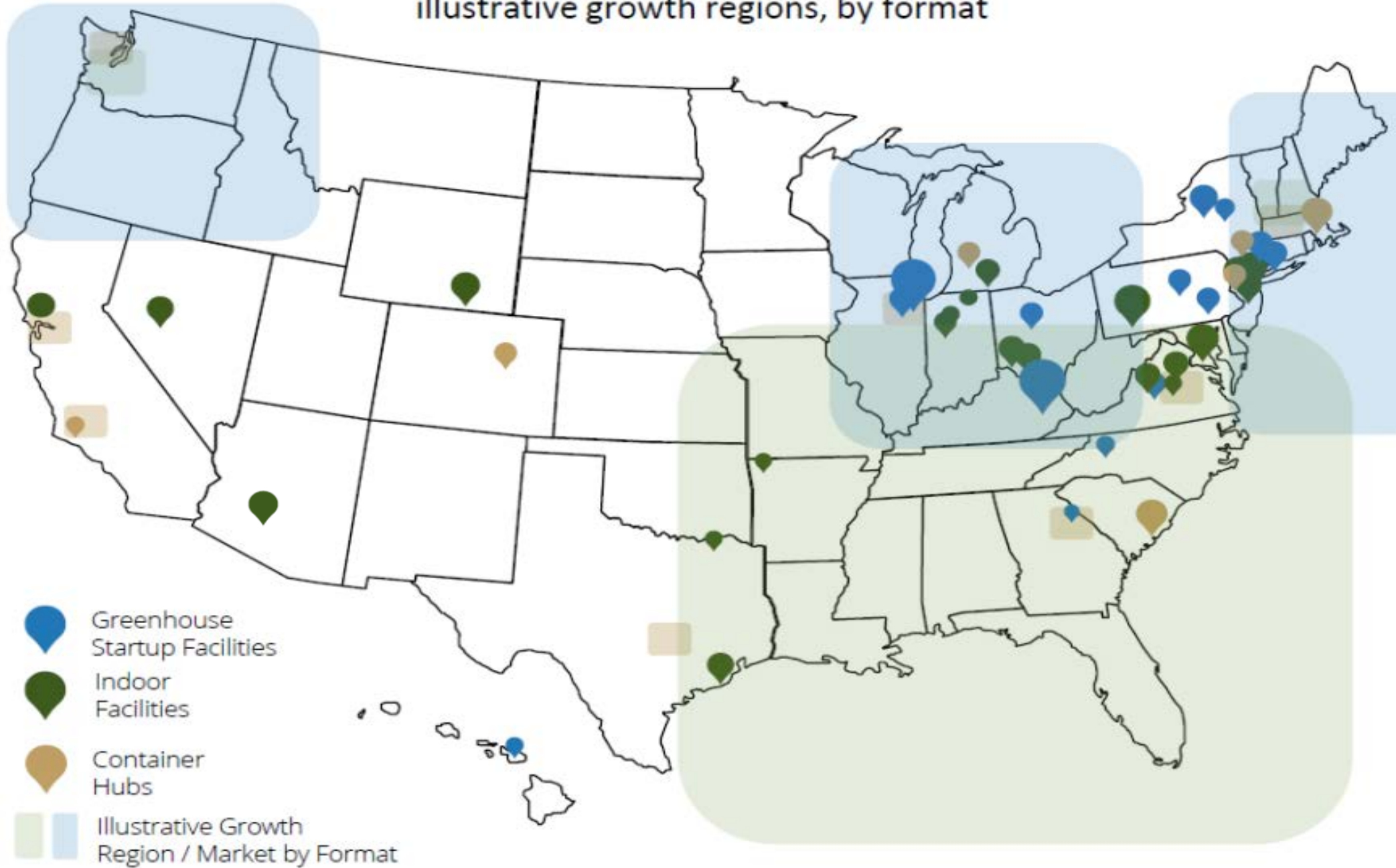


Shenandoah Growers, VA, USA



80 Acres Farm, OH, USA

Current CEA startup penetration and illustrative growth regions, by format



Maximize outputs while minimizing inputs

Resource use efficiency (RUE)

“Maximize the plant growth with the minimum resource inputs, help contributing to minimum emission of environmental pollutants and minimum costs for the resources used”

$$RUE = \frac{\text{Crop Yield}}{\text{Resources Consumed}}$$

INPUTS

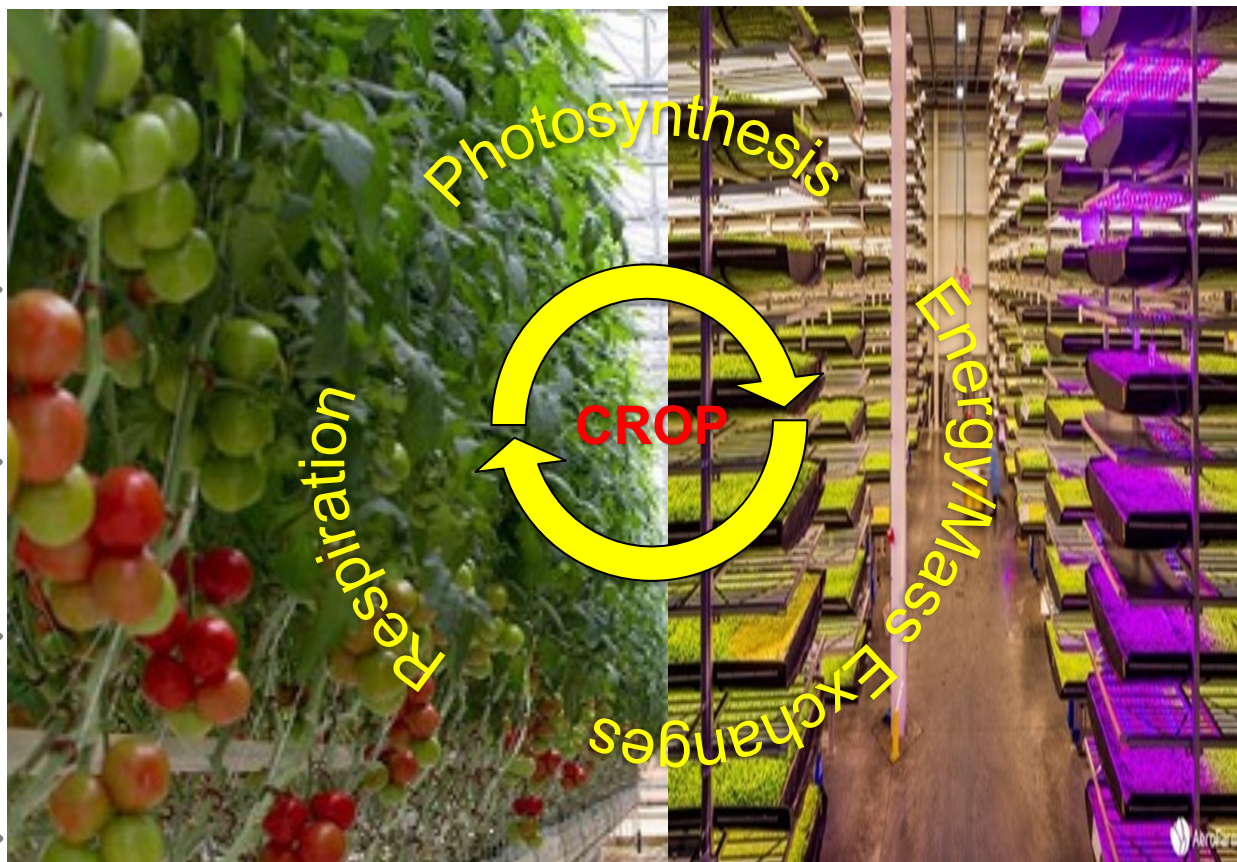
Energy

Water

CO₂

Fertilizer

Labor



OUTPUTS

Edible biomass

Non-edible biomass

Nutrients & water

Transpired water vapor

Automation/Robotics in Greenhouse Systems

Automated Crop diagnostics and Decision Support Systems (DSS)

IoT, Cloud Computing, Artificial Intelligence, Augmented and Virtual Reality



(PlantEye)

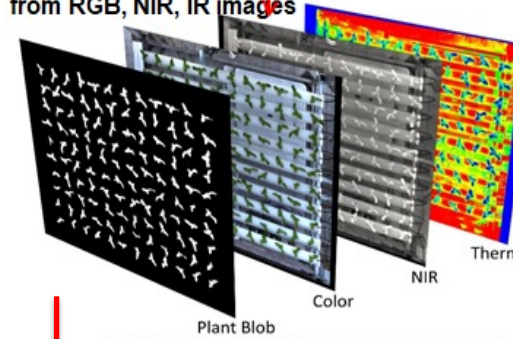


(TopCrop Monitor, Priva)



(U/CALS-CEAC)

19 Crop Features Monitored/Determined from RGB, NIR, IR images



AgEYE



(CropView, Ridder)



IUNU



Automation/Robotic in Vertical Farming



Innovating next generation and sustainable CEA technologies

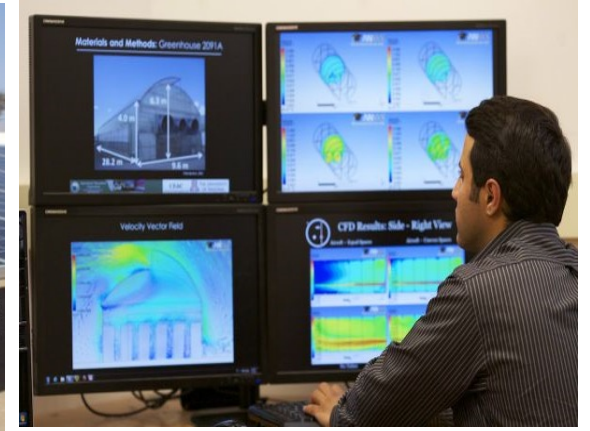


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Educating Future Farmers, Engineers, and Leaders of CEA



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