Global Food Security
Challenges & Solutions

Prof. Joel Cuello
Biosystems Engineering
TWO
GAME-CHANGING
INNOVATIONS

VERTICAL FARMING

CELLULAR AGRICULTURE
VERTICAL FARMING
1994
NASA John F. Kennedy Space Center
Cape Canaveral, Florida
Closed Ecological Life Support System (CELSS)
Closed Ecological Life Support System (CELSS)
Cosmo Plant
Tokyo, Japan
Paradigm #1

The Warehouse Vertical Farm
Techno Farm Keihanna
30,000 heads of lettuce per day. (since 2015)
• Saves 80-95% of water
• Arable land not needed
• Requires significantly less land area
• Less fertilizer
• No pesticides
• Consistently optimal productivity and crop quality
• 24/7 and 365 days per year
• Independent of location
• Independent of climate, weather and season
Sustainability-Powered Vertical Farms
Productivity per Unit Resource Use

Cuello’s Law
Cuello’s Law

Crop Productivity per unit resource use in a tech-dense vertical farm must double every 4-5 years.

- Per Liter WATER
- Per kWh ENERGY
- Per m² LAND
- Per kg NUTRIENTS
- Per m³ VOLUME
- Per Hour LABOR
Paradigm #2

The Modular Vertical Farm
Shellbe
Dittel Engineering
Solar-Powered

ARIZONA Green Box

by Cats in the Green Box

Prof. Joel L. Cuello
The V-Hive Green Box
The Go-Vertical Farm
LifeGrow Robots (LGBots)
LifeGrow Robots (LGBots)
LifeGrow Robots (LGBots)
DATA ANALYTICS AND AI
• Saves 80-95% of water
• Arable land not needed
• Requires significantly less land area
• Less fertilizer
• No pesticides
• Consistently optimal productivity and crop quality
• 24/7 and 365 days per year
• Independent of location
• Independent of climate, weather and season
CELLULAR AGRICULTURE

CULTIVATED MEAT

PLANT-BASED MEAT
• Since 1961 global meat production has more than quadrupled to more than 340 million tons (UN)

• Intensification of animal agriculture (CAFO)

• About 65 percent of antibiotics in the United States are sold for use on farms
• Only 37 percent of the global protein supply, comes from meat and dairy

• more than 75 percent of land used for food production goes to animal agriculture

• About a quarter of global greenhouse gas emissions are traceable to the food supply chain. Animal agriculture accounts for about three-quarters of those emissions
Cultivated Meat

Cultured Meat

Clean Meat
2013

Prof. Mark Post
Maastricht University
The Netherlands
95% less greenhouse gas emissions

98% less land use

50% less energy input
Cost in 2018 -- $11 per pound!

(The Modern Agriculture Foundation)
Single Zig-Zag Plate

Double Parallel Zig-Zag Plate

Double Opposite Zig-Zag Plate

BiolImagineering Lab
Tyson, the Largest Meat Processor, investing in World’s First Clean Meat Company
Eat Just's Lab-Grown Chicken Gets World’s First Cultured Meat Approval

By Olivia Rosane | Dec. 02, 2020 02:17PM EST
Plant-Based Meat
THE IMPOSSIBLE BURGER
• Significant reduction in greenhouse gas emissions
• Arable land not needed
• Requires significantly less land area
• Significant savings in water
• No antibiotics
• 24/7 and 365 days per year
• Independent of location
• Independent of climate, weather and season
POTENTIAL
UNINTENDED CONSEQUENCE:

Could Significantly Widen the Gap between the Haves and Have Nots among Nations in Food Given their Large Discrepancies in Scientific and Technical Capabilities
Qatar
DEMO FARM – Template/Incubator for Industrial Farms

INDUSTRIAL FARMS – Intensive High-Tech Farms in Qatar
Production of Microalgae In AirAccordion Photobioreactors for Food, Feed, Nutraceuticals, etc.

Prof. Joel L. Cuello
Global Capacity Building in Food Security Requires Far More than Just Sharing Technology Innovations
West Bank, Palestine
Algae as Feed:
Government-Industry-University Partnerships

SUSTAINED VALUE CREATION

Government

Incentives

Industry

Grants

Contracts

R&D Universities and Centers
Al Quds Open University

Dr. Younes Amr
President
Government

Companies

Incentives

Grants

Contracts

SUSTAINED VALUE CREATION

R&D Universities and Centers

Government-Industry-University Partnerships
Palestine Joint Center of Excellence for Strategic Aridland Food and Bioproduction (SAFAB)

Palestine Higher Council for Innovation and Excellence (HCIE)
Al-Quds Open University (QOU)
The University of Arizona (UA)
Philippines
Excessive Heat
Excessive Rain

Fernanado Vellarino, Farm Manager

Manolo Fortich, Bukidnon
Projected Changes in Temperature and Precipitation in PH by 2050

Changes in annual mean temperature (°C)

- +1.5 Luzon
- +1.4 Visayas
- +1.4 Mindanao

Changes in total precipitation (%)

- +4 Luzon
- +5 Visayas
- +4 Mindanao
FRUGAL-ENGINEERED INDOOR FARMING
Strategic Agriculture

Linking farmers to all critically necessary **Upstream Factors** (innovation, investment, etc.) and **Downstream Factors** (market linkages, etc.) to make their business enterprises **sustainable** economically, environmentally and socially

Prof. Joel Cuello
Strategic Agriculture

Investment

Technology & Innovation

Economy of Scale
Management
Marketing
Markets
Villa Conzoilo Farmers’ Association
Capacity Building for Food Security

#1 Sharing technology innovations

#2 Building government-industry-university partnerships

#3 Organizing growers associations

#4 Providing business and leadership skills

#5 Establishing linkages to investments and markets

#6 Etc.
Dr. Joel L. Cuello  
Professor of Biosystems Engineering  
The University of Arizona  
Tucson, Arizona, U.S.A.

cuelloj@arizona.edu