Vertical farming and horticulture: Horticulture 4.0

Derek Stewart
Improving Production Systems

Intelligent Production Systems/ Derek Stewart
Horticulture 4.0?

1st: Mechanization, water power, steam power
2nd: Mass production, assembly line, electricity
3rd: Computer and automation
4th: Cyber Physical Systems
Global Challenge

Population of 8.3 billion by 2030 (UN)

Food
50% increase in demand (FAO)

Energy
50% increase in demand (EIA)

Freshwater
30% increase in demand (FAO)

Land
120 million ha needed in developing countries crop production (FAO)

Soil erosion & biodiversity loss
Probability of extreme weather events

- Previous Climate
- New Climate
- Increase in mean
- More Hot Weather
- More Record Hot Weather
- Cold
- Average
- Hot

Probability of occurrence
12-39% of the Earth’s land surface will develop novel climates
Climate Change will hit the staple crops and then the consumer

**IMPACTS OF CLIMATE CHANGE**

By **2030**, nine out of 10 of the major crops will experience reduced or stagnant growth rates, while average prices will increase dramatically as a result, at least in part, due to climate change.

- **MAIZE**: 12% growth rate decrease, 90% price increase
- **RICE**: 23% growth rate decrease, 89% price increase
- **WHEAT**: 13% growth rate decrease, 75% price increase
- **OTHER CROPS**: 8% growth rate decrease, 83% price increase
Climate change – Crop Pests and diseases

- Current problems:
  1. Phytophthora infestans – fungal pathogen causing 'potato late blight.'
  2. Globodera spp. – animal pests known as 'potato cyst nematodes.'
  3. Pectobacterium atrosepticum – bacterial pathogen causing 'potato blackleg.'

- Potential future threats:
  4. Escherichia coli – bacterial pathogen on salad crops causing food poisoning.

BBC NEWS

US & Canada

Five people die in US romaine lettuce E. coli outbreak

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HOW WE'RE HELPING BUILD A SUSTAINABLE PLANET

AGRICULTURE

- = 2020 Goal (100%)
■ = Achieved

<table>
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<tr>
<th>Ingredient</th>
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<tr>
<td>Beet Sugar</td>
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Percentage of our key agricultural ingredients sourced from more sustainable sources in 2016
Strawberry Fields Forever?

No
One key pillar of this change, in almost every part of the world, is the mass adoption of indoor farming.
TODAY GROWING SOME CROPS IN SOME PLACES IS PROFITABLE AT INDUSTRIAL SCALE
Most indoor farming is **economically inefficient** due to the **high power costs**

Outside the developing world **labour costs** are prohibitive

**Productivity is hampered** by the inability to deliver totally controlled environment agriculture

Vertical farming brings a whole new set of **challenges**.
Stacking growing space requires power-hungry automation & mechanics.

Monoculture operation requires tight, balanced environmental control.

Power cost is driven even higher by the offset between lighting and ventilation.

Lots of attention & investment but profitability remains elusive.
So we’ve built revolutionary Power, Comms & Controlled Environment platforms.
We’ve solved the power problem.
Patented 3-phase Power & Communications platform to collapse energy costs,
using IOT to manage Lighting, Ventilation, Gases and Water (TCEA).

50% LESS POWER

We’ve solved the labour problem.
Patented Tower Automation platform to manage stacks of growing trays,
handled by robots for germination and propagation.

80% LESS LABOUR

We’ve solved the productivity problem.
Using Artificial Intelligence our SaaS app lets growers find optimal growing
“recipes” using our platforms, including our patented Ventilation System.

2X–3X YIELD
Growth Tower Platform
Growth Tower Platform

Power & Comms platform enables real-time control of all tower variables via seamless cloud integration.

- Dynamic lighting utilised on each LED strip
- Flexing the lights per LED strip, per tray, per tower, whole farm
- Full closed-loop watering control
- Full closed-loop air sterilisation and conditioning control
- Humidity harvested from air
- CO₂ / O₂ continuously balanced
- Manual or AI-driven recipe creation
- Plants monitored for reaction to recipe changes
- Data capture direct to SaaS platform
- Exception detection and automatic re-set
• Manages Light, Temperature, Water/Nutrients & Gases
• Fully automated Growth Tray systems support all these variables
• 100% robotic handling
• Closed-loop water and air management
• In-tray Ventilation delivers <1ºC variation across the crop
• Artificial Intelligence enables recipe experimentation and optimisation
• IOT enables remote monitoring and control of all systems
• Controls enabled at farm/tower/tray/LED strip level 24/7/365
• Designed to operate anywhere, globally
• Modular Design
• Built in Pairs of Towers
• 60 trays/300m² growing area per tower

• Robot Operated
• Picks
• Places
• Waters
• Inspects
• Samples
• Monitors

• Month 1 metrics (basil)
• 18-23 days to harvest weight vs 28-35 range for greenhouse
• 18 growth cycles per annum vs 12: 50% more
• 680g yield per punnet vs 450g industry standard: 50% greater

= 225% Greater Yield Per Annum
Clear Product Strategy

Vertical Farm

- LED Light strips
- IGS Growth Tower
- IGS Power and Comms Platform
- Mains

IGS Core Platform + IGS Operational Platform + 3rd Party Products = Whole Product
Growth Station Platform
Clear Product Strategy

Horizontal Farm

Core Platform

Operational Platform

3rd Party Products

Whole Product
Growth Station Platform

Same core ‘Power and Comms’ platform enables real-time control of all station variables via seamless cloud integration

- Growth Stations have many of the tools developed within the Growth Towers
- Dynamic lighting utilised on each LED strip
- Flexing the lights per LED strip, per tray, per station, whole farm
- Direct ventilation per tray
- Allows single storey retro-fit
- Manual handling
- Manual or AI-driven recipe creation
- Plants monitored for reaction to recipe changes
- Data capture direct to SaaS platform
Fully IOT-enabled
No Cables. No Computers. No Capacitors.

• Radical cost savings: power, installation, maintenance
• Supports LED dimming, pulsing and colour-mixing
• No loss of efficiency
• Power factor ≈ 1 @ dimming range 100%-15%
• Almost no harmonics: balanced phases
• Giving significantly greater productivity: yield, quality, consistency
• Communications makes every device addressable / IOT-enabled
• Enables remote control of every device
• Data capture enables “growth recipe” optimisation
- Growth Station Controller app:
  - Easy to use with little or no training
  - Direct control of the lights
  - User can build arbitrarily complex sequences of lighting

- IGS Portal web interface:
  - Richer functionality
  - Facility management
  - Supports both production and experimentation
Machine Learning Platform Road Map

24/7 real-time data from 1,000’s of data points, measuring everything from soil moisture to regional power conditions.

IGS leverages a scalable, high performance AI platform architected for large volume spatio-temporal data (IOT, stress sensing, imagery analysis, etc.) to optimize operational efficiency, crop profiles and even supply chain demand management.

Real-Time Operations

- **Monitoring data** (environmental, lighting, watering, HVAC)
- **Operational data** (timing of all events, tasks scheduled and actioned)
- **Comparing** planned events vs actual events vs risk
- **Predictive maintenance** enabled throughout
- **Managing** overall lighting, ventilation, irrigation, operational efficiency
- **Optimising power** consumption and growing conditions
- **Flexing with the grid** to deliver demand side response*

Growth Recipes

- **Dynamic Recipes**: all growing attributes can be planned for each crop family and variety
- **Recipe Timing**: can be run on different trays, at same or staggered timing. A time machine for scientists and market flexibility for production
- **Rapid Experimentation** correlated to target outputs (taste, growth cycle, shelf-life, etc) by controlling all TCEA inputs
- **100’s of experiments** per tower
- **Optimising growth cycles, nutrient content and specific taste profiles**

Supply Chain

- **Forecast customer demand** based on actual historical to predict optimal crop management and planting schedules*
- **Leverage** across 100s or 1000’s of geographically disparate vertical systems and markets*
- **Empower** large scale growers to flex crop capacities seamlessly*

* work in progress
Cost Reduction = Key To Market Growth

MATCHING MARKET DEMAND

Consumer pull *not* technology push
Price is the key

Premiums must provide value
Quality: Taste, Nutrition, Food Safety
Consistency

Retailer benefits
Less wastage
Fresher
Fewer food miles
Long Day Veg – all year round

- Crops use predominantly blue and red parts of the light spectrum
- Get fundamental, natural, changes in plant growth and phytochemistry (flavour, storage properties, nutrient density; growth rate; ripeness) by altering the ratios, timing and duration of different wavelengths
Making Indoor Ag Profitable

IGS’ unique technology drives costs down and yield up, further than any competing system.

- Reduce Power costs with Photon Optimisation
- Smart Power Management
- Reduce Labour costs by Automating Scaling
- Tech & plant science will deliver Higher yields Better quality Greater consistency
Total Control environment agriculture

- Higher plant densities; higher nutrient density; faster growth and more crops per annum

**GROWING LOCALLY, GLOBALLY**
- Producing beside the market collapses food miles, cutting costs
- Increases food security, by reducing dependency on imports
- ‘Farm to fork’ within hours every day, 365 days of the year, increasing both freshness and shelf life, reducing storage

**BETTER QUALITY**
- Product appearance, nutritional qualities and taste are improved and remain consistent year round
- Disease-free growing eliminates the need for pesticides
- Semi-hydroponic techniques eliminate the need for washing, reducing contamination

**SAVING NATURAL RESOURCES**
- Small footprint allowing production close to end-markets
- Highly efficient growing media and temperature management reduces water consumption by more than 90% with minimal effluent
- Large reduction in wastage compared to conventional production

**DECLINING COST**
- Driven by the collapsing cost of LEDs and improving electrical efficiency
- Compression of the value chain reduces number of participants taking a margin
- Production matched to consumer demand, reducing wastage
- Integrated automation reduces labour
Conclusions

• Food Security is becoming a crucial issue.
• The treats of climate change and extremes are evident and increasing.
• A game change is required in food and crop product production
• The emergent vertical farming system *IS* that game change
• VF can both produce food (and products) and be used to breed climate resilient varieties for conventional agriculture.
• The system software, energy management and light control makes sustainable profitable production assured.
ADVANCED PLANT GROWTH CENTRE

Deliver increased commercial, economic and environmental benefits to the agricultural, food and drink sectors in the UK and Internationally by innovative use of precision controlled environment technologies.