Feeding the Future: Sustainable Urban Agriculture/Vertical Farming

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Outline

- Introduction
- What is the vertical farming?
- Technologies
- Types of vertical farming
- Case study
- Questions
The School of Animal, Rural & Environmental Sciences
Nottingham Trent University
The Queen’s anniversary prize for higher and further education

2015

A comprehensive and multifaceted approach to global challenges of food security
International Conference on Vertical Farming and Urban Agriculture
Nottingham, 9-10 Sept 2014
Chelsea flower show
Gold medal was awarded
Our challenges in the 21st century

• Climate changing (extreme weather is becoming frequent and severe)

• Increasing global population (7 bn people now, 9-10bn people by 2050)

• Land degradation (natural processes, human activity - water erosion, soils etc, costs ~ $40 billion annually)

Need to feed more people on limited agricultural land

Source: Bord Bia, Irish Food Board
Within 20 Years, **80%** of population will live in cities or suburbs
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Vertical farming & urban agriculture

“.......indoor agricultural strategies to growing food in protected environment (buildings, glasshouse......)”

New hope for global food security
What is the vertical farming?

- Cultivating plants or crops within a skyscraper building, greenhouse year round.

- Advanced technologies (hydroponics, aeroponics, LED light, automated multi-tier vertical growing systems).

- Vertical Farming is “Modern” and “Sustainable” for creating an eco-city.
Benefits from vertical farming

- **10x**
  - Up to 10x more output compared to average FARM OUTPUT in Singapore of 90 tonne per ha per year

- **95%**
  - Uses only 12 litres of WATER to produce 1 kg of vegetables and no wastage due to run off

- **$0.05**
  - Cost of ELECTRICITY per kg of vegetables produced

- **50%**
  - Use less than half the LABOUR compared to traditional farming to produce the same output

- **75%**
  - INPUT MATERIALS are calculated and there is no wastage due to water run off

Note: Numbers are based on our comparison to local leafy vegetable farmers
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Vertical farming tool box

- Hydroponics
- Aeroponics
- Drip irrigation
- Automation

- Waste-to-energy
- Water recapture
- Passive energy
- LED lighting
Growing system - Hydroponic

Deep flowing tech (tomato), Nutrient film tech (Lettuce)
Growing system - Aeroponics
Growing system - Vertical culture
Saving-energy in Greenhouse

Application of ground source heat pump in Greenhouse
Traditional plant growing lights

-Metal Halide (MH) lights with
  • toxic substances,
  • bad recycling,
  • lifetime < 10,000 hrs, as well as
  • high power consumption and excessive heat generation;

-High Pressure Sodium (HPS) lights with
  • mercury and other toxic substances,
  • bad recycling,
  • lifetime < 18,000 hrs
LED light for plant growth

- LED (light-emitting diode) is a semiconductor light source
- LED provides precise light spectrum from blue (450nm) to red (660nm)
- Achieving significant power savings (80% of power savings) - small size, durability, long lifetime, and cool emitting temperature
The effects of blue light proportion on plant growth

<table>
<thead>
<tr>
<th>Blue(%)</th>
<th>CK</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
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<td>18</td>
<td>27</td>
<td>36</td>
<td>45</td>
<td>54</td>
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</table>

100% blue light treated:
extended hypocotyl petiole
The effects of green light on plant growth and quality in lettuce

<table>
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<tr>
<th>Treatments</th>
<th>Total phenolic compounds (mg g(^{-1}); FW)</th>
<th>Carotenoids (mg g(^{-1}); FW)</th>
<th>DPPH</th>
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<td>0.132(^{b})</td>
<td>3.16(^{a})</td>
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<td>W-CL</td>
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<td>0.115(^{cd})</td>
<td>2.82(^{c})</td>
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</table>
Automation control
Intelligent automated system

Smart Hardware

- FUN
- EASY

WAY TO

Cloud Service

- Manage your plants and get safe food

Keep indoor green and eco-friendly

Mobile Control
Harvesting vegetables by robotics
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Vertical farm (indoor) category

- Hydroponic Greenhouses
- Vertical Farms
- Container Farms
- In Home Systems
Hydroponic greenhouse

- Hydroponic growing
- Use sunlight
- Multi-layers vertical growing

- ETFE roof
- Automated control
- Energy saving
In home systems
Aquaponics for water/nutrient reuse
Green wall
Special cultivation

**Sweet potato in the air:** Completely change the traditional model of cultivation, plant life of up to 5 years, more than 1 ton yield/plant
Vertical arming for others

Aircraft carrier & submarine

NASA project

Desert (Sahara Forest Project in Qatar)
The rise of vertical farms

Skygreens Vertical Farm – in Singapore
Korea’s vertical farms – Seoul, Korea
Nuvege – Kyoto, Japan
National Urban Agriculture Park – Beijing, China
Cervesca 2 story VF – Seattle
3 story VF – Jackson, Wyoming
GrowUP & Underground Growing – London, UK
SkyGreens- in Singapore

- *World's first commercial VF farm*
- **Mr Jack Ng** the founder of Sky Greens, started the building in 2009, and commercialized in 2012
- The A-Go-Gro vertical systems which are 9m in height (3 *storeys*) in protected greenhouses.
SkyGreens- in Singapore

- Sky Greens Retail Pack – leafy vegetables
  - fresh, safe, eat local, eat well
Seoul, Korea
Scientists in South Korea are developing a farming system that could allow food to be grown in any climate, a project that becomes increasingly pressing as the world's population reaches new heights.
Plant Factory, Nuvege Kyoto, Japan
City farms in USA

Jackson, Wyoming

MIT, City Farm

AeroFarm, New Jersey
The challenge in vertical farms

• More expensive than traditional farming methods
  o High energy consumption is (lighting, heating and power supply)
  o High capital costs associated with the technology

• Can we solve the problems?
  o Increasing resources (energy/nutrients/water) use efficiency
  o Intelligent automated control system
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