The University of Nottingham
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NOTTINGHAM TRENT UNIVERSITY

Feeding the Future: Sustainable Urban Agriculture/Vertical Farming
未來糧食保障：可持續的城市垂直農業

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Nottingham Trent University, UK

InnoCarnival, Hong Kong, China,

30th October 2016

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

2012

A comprehensive and multifaceted approach to global challenges of food security

Global Top 100 University

INTERNATIONAL CONFERENCE
VFUA 2014
THE UNIVERSITY OF NOTTINGHAM

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International Conference on Vertical Farming and Urban Agriculture

Nottingham, 9-10 Sept 2014

2014

Chelsea flower show

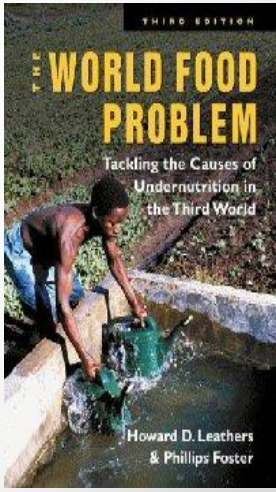
Gold medal was awarded

2013

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

Skygreens

ote: 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

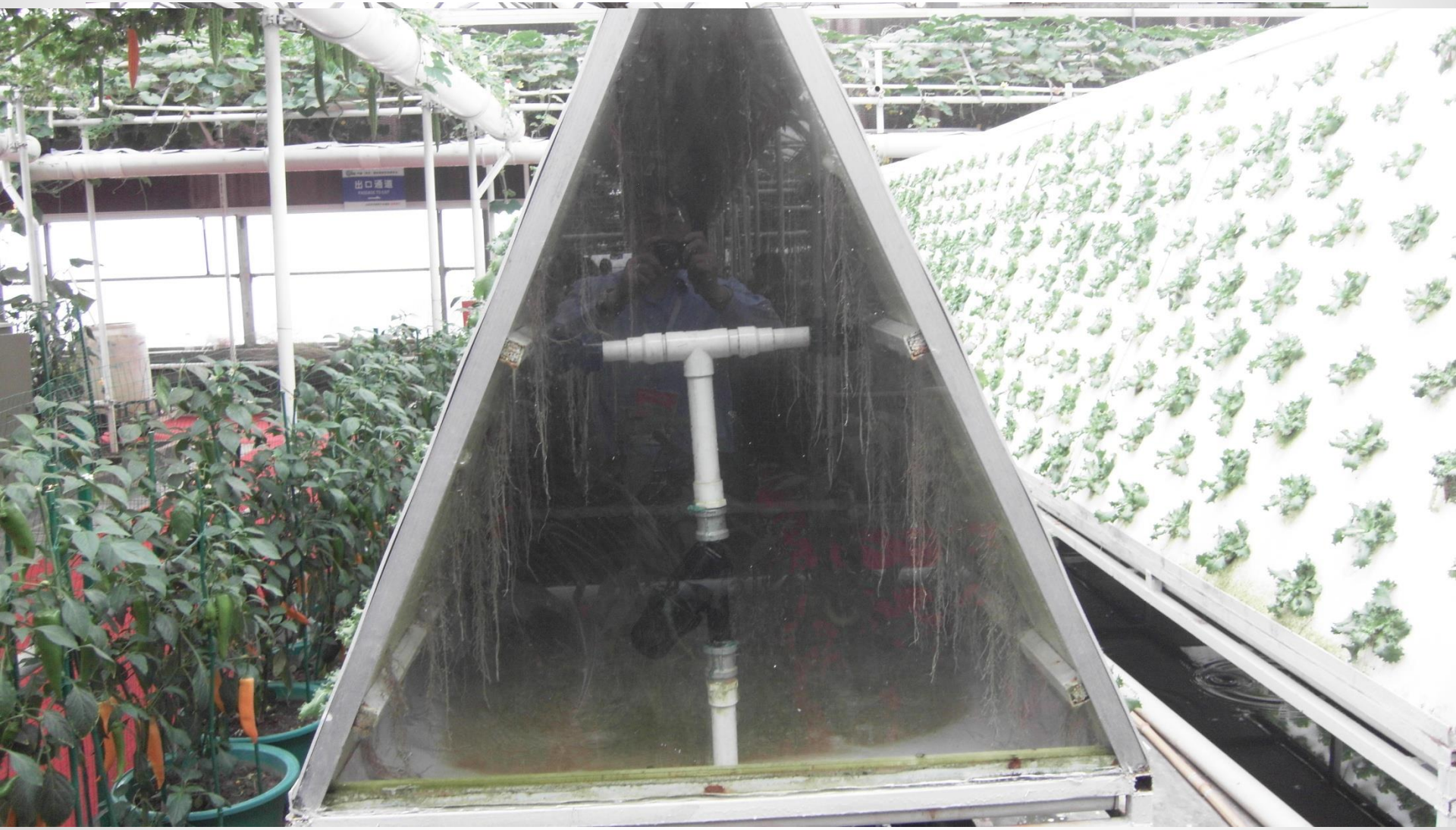
Passive energy

LED lighting

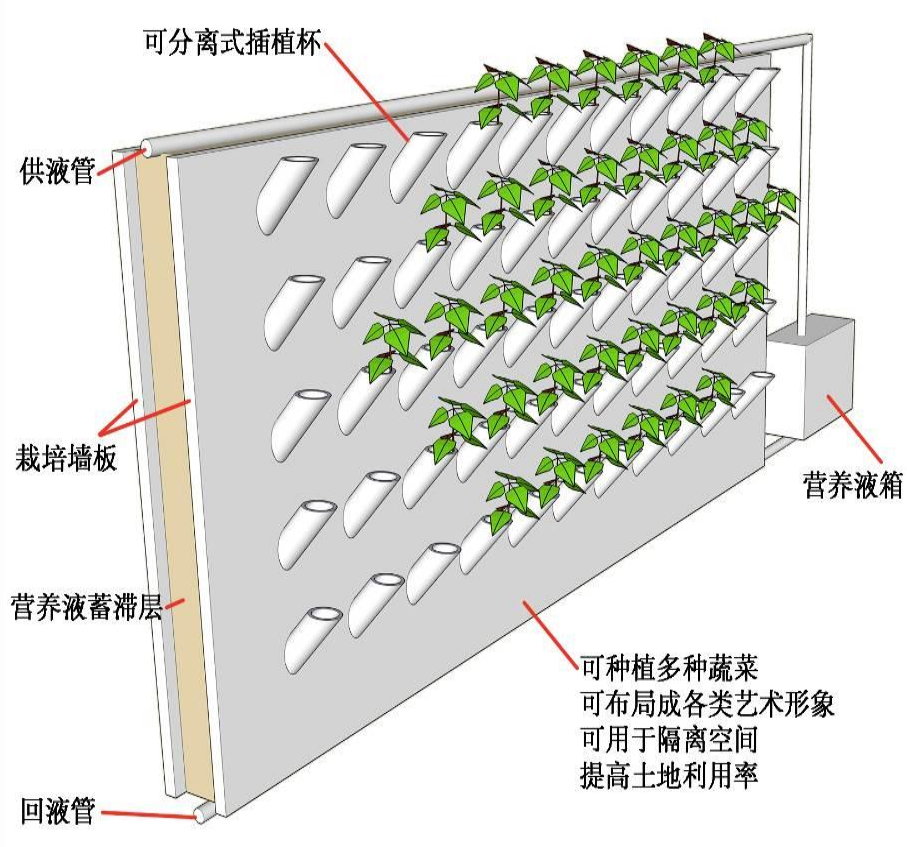
Growing system - Hydroponic

Deep flowing tech (tomato)，Nutrient film tech (Lettuce)

Growing system - Aeroponics

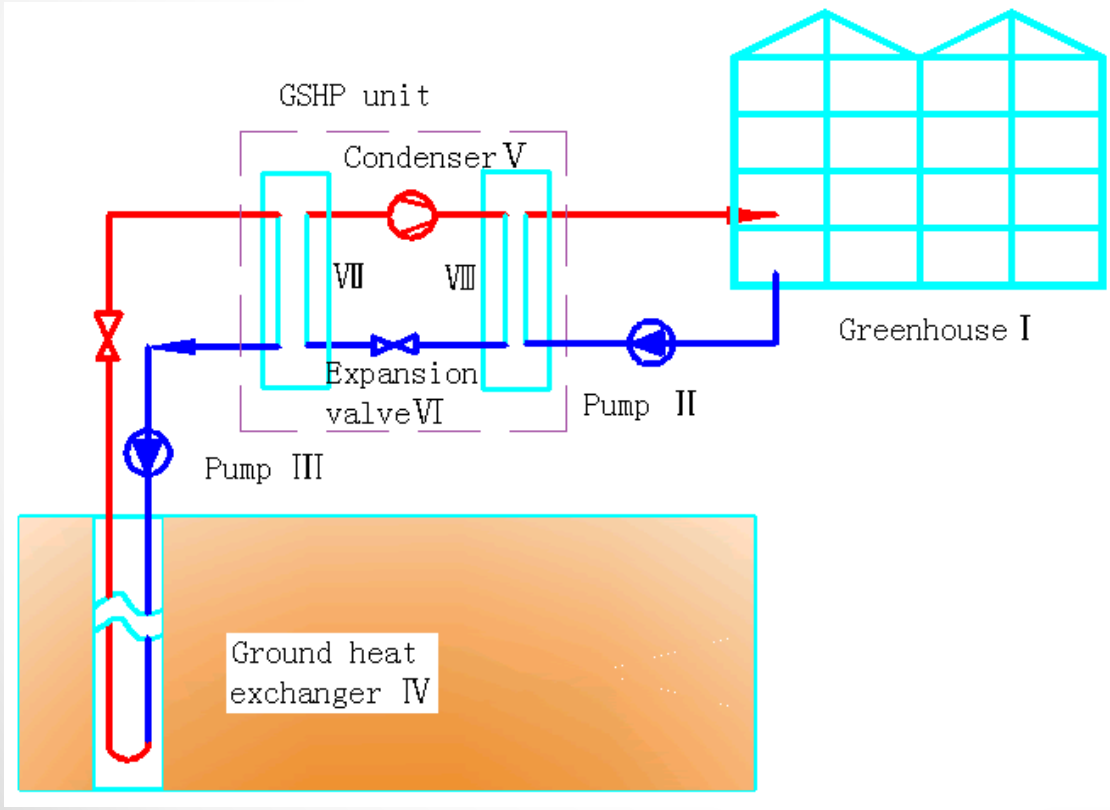


Growing system - Vertical culture



Saving-energy in Greenhouse

Application of ground source heat pump in Greenhouse



Traditional plant growing lights

-**Metal Halide (MH) lights with**

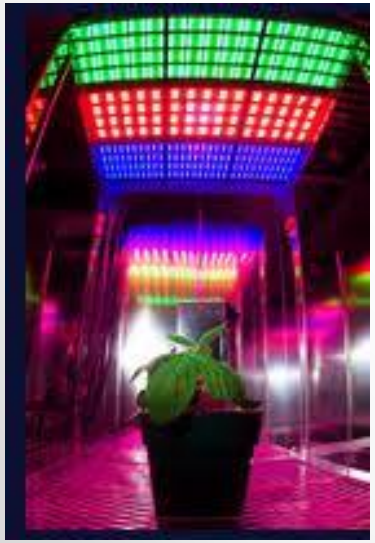
- toxic substances,
- bad recycling,
- lifetime < 10,000 hrs, as well as
- high power consumption and excessive heat generation;

-**High Pressure Sodium (HPS) lights with**

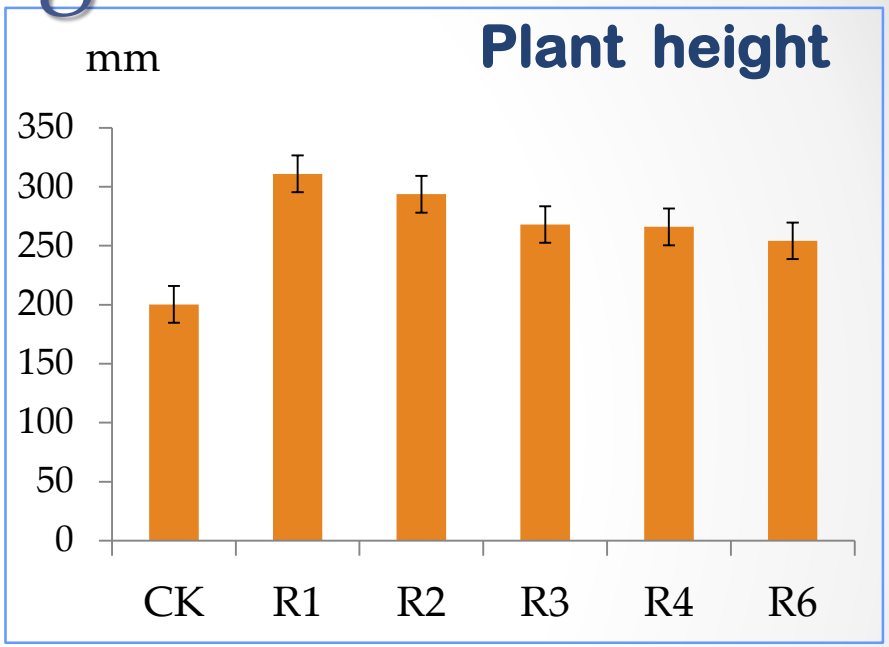
- mercury and other toxic substances,
- bad recycling,
- lifetime < 18,000 hrs

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



	CK	R1	R2	R3	R4	R5	R6
Blue(%)	/	9	18	27	36	45	54

100% blue light treated: extended hypocotyl petiole

The effects of green light on plant growth and quality in lettuce

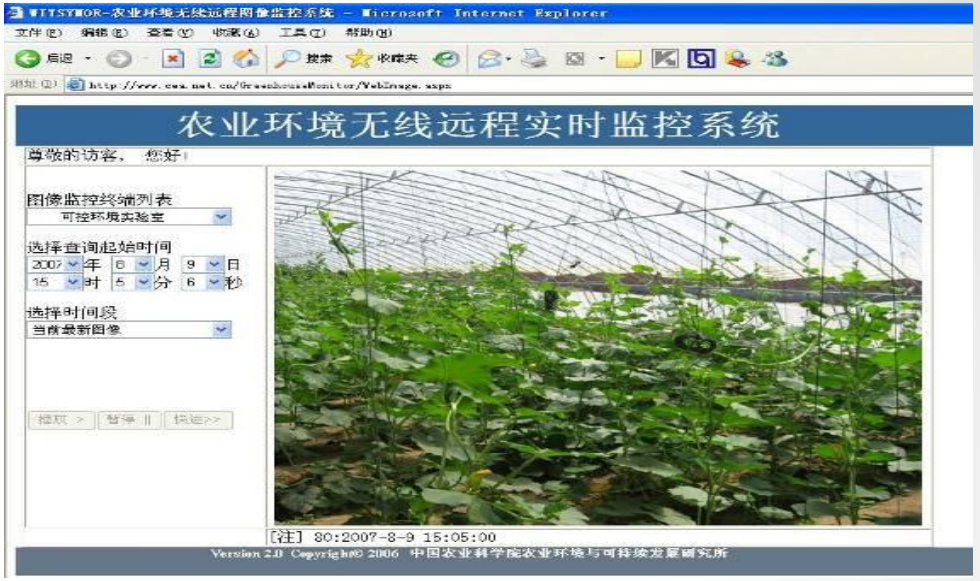
White RB RGB

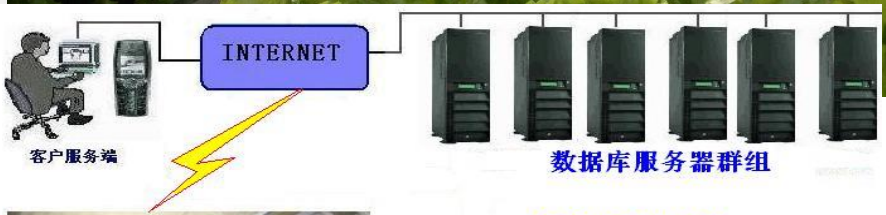
+ Green

- Green (RB)

Treatments	Total phenolic compounds (mg g^{-1}; FW)	Carotenoids (mg g^{-1}; FW)	DPPH
W-CK	1.44^{bc}	0.132^{b}	3.16^{a}
W-CL	1.50^{b}	0.128^{b}	3.20^{a}
RB-CK	1.55^{b}	0.125^{bc}	2.70^{c}
RGB-CL	1.73^{a}	0.149^{a}	2.93^{b}
RB-CL	1.51^{b}	0.115^{cd}	2.82^{c}

Automation control





Intelligent automated system

Smart Hardware

Cloud Service

Mobile Control

A

- FUN
- EASY

WAY TO

- Manage your plants and get safe food
- Keep indoor green and eco-friendly

Harvesting vegetables by robotics

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Vertical farm (indoor) category

Hydroponic greenhouse

- ETFE roof
- Automated control
- Energy saving

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

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)

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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**

Cevesca **2 story VF – Seattle**

3 story VF – Jackson, Wyoming

GrowUP & Underground Growing– London, UK

SkyGreens- in Singapore

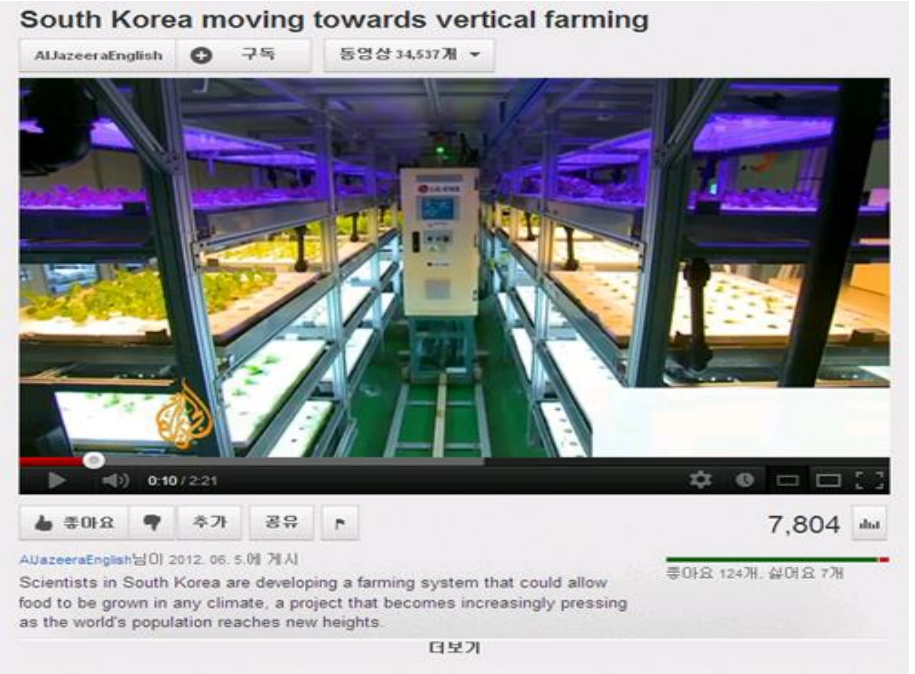
- **World's first** commercial VF farm
- **Mr Jack Ng** the founder of Sky Greens, started the building in 2009, and commercialized in 2012
- The A-Go-Gro vertical systems which are 9m in height (**3 storeys**) in protected greenhouses.

SkyGreens- in Singapore

- Sky Greens Retail Pack – leafy vegetables
  - fresh, safe, eat local, eat well

Seoul, Korea

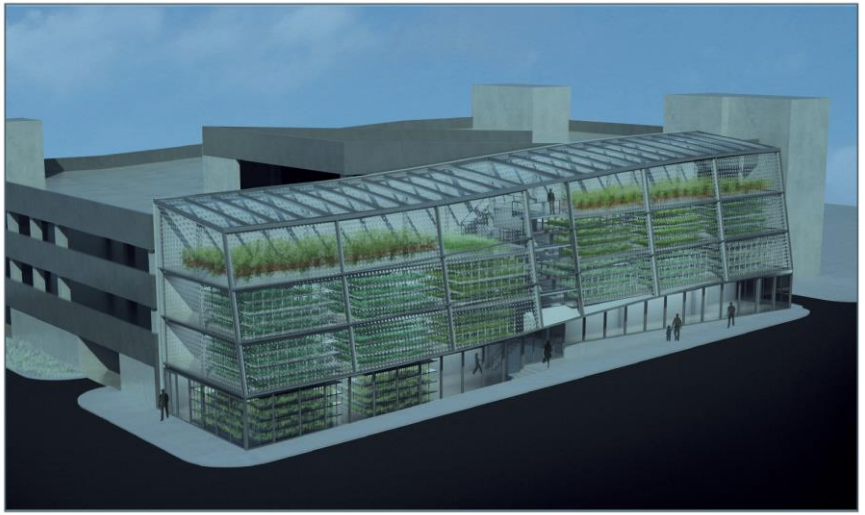

The Korea Herald


South Korea moving towards vertical farming
AlJazeeraEnglish
구독
동영상 34,537개
0:10 / 2:21
좋아요
추가
공유
7,804
AlJazeeraEnglish님이 2012. 06. 5.에 게시
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.
좋아요 124개, 싫어요 7개
더보기

Plant Factory, Nuvege Kyoto, Japan

City farms in USA

MIT, City Farm



Jackson, Wyoming

Vertical Harvest Jackson, WY

AeroFarm, New Jersey

The challenge in vertical farms

- **More expensive than traditional farming methods**
  - High energy consumption is (lighting, heating and power supply)
  - High capital costs associated with the technology
- **Can we solve the problems?**
  - Increasing resources (energy/nutrients/ water) use efficiency
  - Intelligent automated control system

Acknowledgements

University of Nottingham:

- Nanjun Jiang (PhD student)
- Lorna McAusland (Postdoc)
- Steven Grundy (PhD student)

Chinese Academy of Agri Sci:

- Qichang Yang
- Zhonghua Bian (Postdoc)