Protected Cultivation of Fruits and Vegetables
Opportunities and Challenges

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Horticulture Innovation Lab

- Managed by UC Davis since 2009
- Portfolio of projects to address needs in horticulture in emerging economies
- Grants awarded to U.S. university researchers to work with developing country partners
- $35 million budget over 10 years
Growing Urban and Peri-Urban Population

• 9.1 billion world population estimated in 2050
• Biggest increases in urban and peri-urban areas
• Insufficient food and employment opportunities
What is Protected Cultivation and can it help to Fill this Need?
Protected Cultivation

• Allows for the production of horticulture crops in any environment
• Distinguished by height and technology
  • Height
    • Row covers
    • Low tunnels
    • High shelters
  • Technology level
    • Low – environment is poorly controlled, no heating or cooling
    • Medium – semi-climate control with simple systems, irrigation or hydroponics
    • High – controlled environment agriculture, regulates air and root zone temperatures, RH, light, gases

Nordey, T., Basset-Mens, C., De Bon, H. et al. 2017
Background and Trends – Protected Culture

• Protected culture techniques used for millennia
• Introduction of plastics (specifically polyethylene) in 1950 led to more widespread-use
• 405,000 ha of greenhouses globally (FAO, 2013)
  • More than double the amount in 1989
  • Due in large part to availability of plastic for greenhouses
Protected Culture Terms

**Protected Agriculture**
- **General Term**

**Low tunnels and row covers**
- Mainly for food crops grown in the field

**Greenhouse**
- For food and ornamentals
  - **Unheated, passive venting**
    - Usually poly/plastic/net
  - **Heated or cooled**
    - Glass, rigid plastic, poly or net

- **Hoop House**
  - Plants in containers

- **High Tunnel**
  - Crops grown in ground

Janke et al 2017
Level of protected culture technology in LMICs varies significantly amongst countries with different economic classifications

Proportion of low-tech, medium-tech and high-tech protected cultivation varies due to:

• Government support
• Outside investment
• Domestic wealth coupled with potential for premium domestic prices
• Potential for export
Case Study - Adoption of Protected Cultivation in LMIC – Government Support in Egypt

In 1986 established National Committee for Protected Cultivation

- Total area covered by Protected Cultivation increased from 1658 ha in 1985 to 12,363 ha in 1991 (7 yrs)
- Profitability of greenhouse production can shift, demanding either upgrades in protected culture systems for increased efficiency and/or higher yields, or shift to new crop

(Mohamed & El-Nagger, 2018; Hadir 2013)
Case Study - Adoption of Protected Cultivation in LMIC – Government Support in China

China (Shanghai)

- 90% of global greenhouse production is in China (2.6 million hectares)
- In Shanghai, specialized high-value vegetables (27% of all vegetables) are grown in greenhouses
- Since 1990, vegetable production has gradually moved out as city has expanded.
- Only 10% of vegetables came from per-urban areas in 2000; rest grown 30-60km outside city
- Shanghai’s self-supply of vegetables has decreased from 100 to 60% due to availability of cheaper produce transported from outside city-limits.

(Yi-Zhang and Zhanen 2000)
Low-Tech Protected Culture – Horticulture Innovation Lab

High Tunnel

Low Tunnel

Row Cover
Case Studies – Horticulture Innovation Lab

**Kenya** – Dr. Vance Baird (MSU) and Dr. Thibaud Martin (CIRAD)

- Evaluated return on investment in production of tomato, French bean and cabbage in Kenya - 28 farmers under actual farming conditions
- Farmers provided one metal-framed net-house covering 160 m² and trained on crop management in the net-house (innovation package)
- Net-houses can achieve profitability rates up to 2 times higher (greater yield and quality, less insecticide inputs)
- Cost-benefit ratio
  - Subsistence farmers <1
  - Entrepreneurial farms with resources to invest in other technologies and inputs - 3
- Farmers can generate the necessary resources to pay back a loan on a net house (price $1500) with 2 to 4 harvests (one harvest per year), on average
  - Interest rate 12%
  - Down-payment of 15%
Cambodia - Dr. Karen LeGrand, UC Davis and Royal University of Agriculture

- Net-houses purchased by farmers using loans from savings groups
- 400 m² - $1,200 to $1,800 (depending on materials used – bamboo, metal, wood)
- Loans paid off in as little as 3 months
- Crops produced inside the nets have exceptionally high quality and are mostly pesticide free - sold for a premium
- Extended the growing season, protected the crops from downpour, shading effect was beneficial during dry season
- Leafy vegetables and herbs were primarily grown.

Lessons-learned
- Farmers need to be trained in proper ground preparation to kill soil pests before they put the net up so pests don't arise out of the soil
- Seedlings should be grown under nets as well before transplanted
Benefits of Protected Cultivation

• Allows for off-season/non-ideal climate production of fruits and vegetables
• Extends season of production
• Protects crops from heavy rain and winds
• Allows for production of fruits and vegetables in urban and peri-urban environments that are not currently suitable for open-field production
• Can boost yields and conserve water
• Can reduce pesticide application/Prevent pest infestation
• Reduced exposure to pollution in air and soil
Advances in Protected Culture

- Netting with various colors intended to deter pests
- UV Blocking films to reduce pest infestation
- Use of biological control and pollinizers inside structures
- Greenhouses with reusable/recycled water systems
- High efficiency lighting, LED lighting, temperature control
- Mechanization to reduce need for labor
Considerations for Protected Culture in LMIC

• **Upfront costs**
  - Low-tech protected culture systems are frequently the only viable option for Low Income countries
  - Government assistance may be needed for medium- and high-tech systems in Middle Income countries
  - Land in urban and peri-urban areas is more expensive due to high populations

• **Market**
  - Achieving a premium for products either domestically or by exporting is needed to recoup fixed costs
  - Profitability of vegetables and fruits produced should be considered prior to implementation due to high input costs.
Upfront Costs Vary with Level of Technology

• Row-cover netting in Benin and Kenya - $0.4-0.7 per m²

• Greenhouses (India)
  • Low Technology (passive temp. control) with Greenhouse Film – $2.50 per m²
  • Medium Technology (Electricity, low-cost temperature control) with Greenhouse Film - $7.50 per m²
  • High Technology (Temperature control, electricity, lightning) with Greenhouse Film – $30 per m²

• Nepal – Bamboo frame, Greenhouse Film - 100m² $110-130 ($1.1 to 1.3 per m²)

• Cambodia – 400 m² nethouse $1,200 to $1,800 ($3 to 4.5 per m²)
Considerations for Protected Cultures in LMIC

• Operational Costs
  • Is urban and peri-urban production more competitive than rural production?
  • Cost of labor in peri-urban and urban LMICs will likely be higher than in rural areas
  • Reduced transport costs to reach urban markets can help mitigate labor costs
  • Electricity/energy costs can affect profitability - is the climate suitable for low technology protected culture?

• Crop management/IPM is key
  • Yield increases are significantly dependent on crop management and IPM practices
  • Pest pressure can be greater in high tunnels compared with open-field plots because predatory pests are also excluded.
Promoting Protected Cultivation in LMIC

• Access to Materials - In locations of low-supply, costs can be high and proper material challenging to acquire.
• Capacity Building – Increase knowledge and technical skills for production of vegetables and fruits in protected cultivation
• Policy – Encourage government policies supporting the use of protected cultivation (land, water, enabling environment)
• Market
  • Identify niche markets, domestic and export, that could generate sufficient revenue to recoup the upfront costs of protected cultivation
  • Determine potentially successful crops for each area based on climate, crop requirements, technology level required, and market price potential
Available Literature


- FAO (2009) How to Feed the World in 2050


Available Literature, Continued.

- Anonymous, 2013, Natural Resource Management Approaches and Technologies in Nepal: Technology – A low–cost polyhouse for tomato production in the rainy season, ICIMOD
- Anonymous, date unknown. Low Cost Green Houses for Vegetable Production
Thank you for your attention!