Investment Decisions in Hydroponic Vertical Farming

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Introduction

- Climate change, rapid urban growth, population growth, global crises, land degradation, and limited arable land are creating serious challenges, including food insecurity and poor access to fresh food in remote areas.
- Controlled environment agriculture, including hydroponic vertical farming (HVF), offers innovative solutions to growing climate and supply-chain challenges.
- HVF offers efficiency and year-round production but faces high capital and energy costs.
- Profitability of HVF is region-specific, shaped by prices, costs, and discount rates.

Research Objectives

- To evaluate the **investment potential of large-scale hydroponic vertical farming** in three contrasting regions—Manitoulin Island (Ontario), Yukon, and Trinidad & Tobago—by:

i. assessing overall economic feasibility,

ii. quantifying how key financial drivers such as crop prices, input costs, and discount rates affect long-term profitability, and

iii. discussing how investment outcomes change once uncertainty and risk are considered

Stochastic Net Present Value Model

The model incorporates uncertainty; key parameters are modelled as probability distributions.

$$NPV_r^{MC} = \sum_{t=0}^{15} \frac{R_{r,t}(\theta) - C_{r,t}(\theta)}{(1+d_r(\theta))^t} - I_r$$

Where,

$r \in$ {Manitoulin Island, Yukon, Trinidad & Tobago}
$R_{r,t}$:= revenues from crop sales in region r.
$C_{r,t}$: operating & input costs in region r.
θ : = Price
D_r:= region-specific discount rate
I_r: = Initial capital cost

Stochastic variables: electricity costs, water costs, crop prices, & discount rates.

Running 10,000 simulations.

Economic Outcome Over a 15-Year Investment Horizon

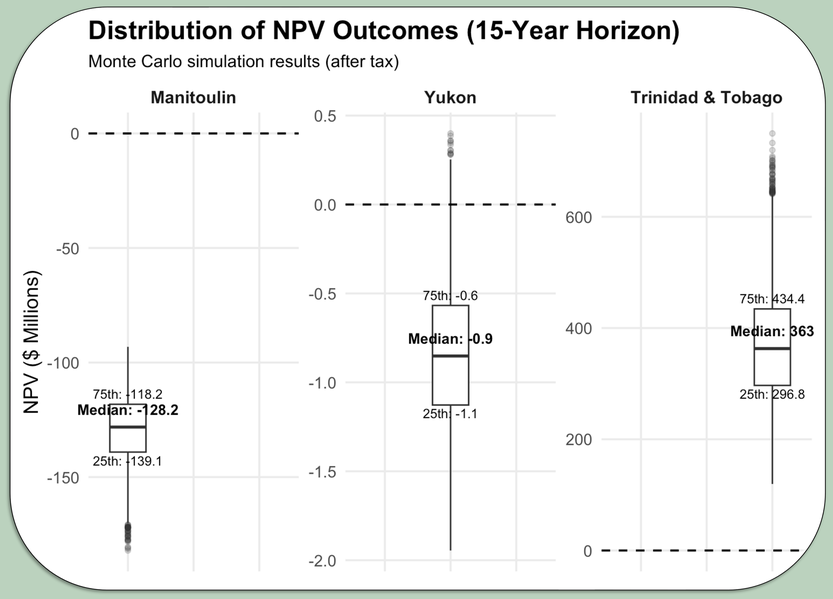

Figure 1: Distribution of Investment Outcomes Under Uncertainty

Results

Manitoulin Island: Persistently negative NPV outcomes reflect high energy costs and limited price premiums, making profitability unattainable under current conditions.

Yukon: While outcomes vary widely, expected NPV remains negative, indicating that economic viability would require significantly lower electricity costs or targeted policy support.

Trinidad & Tobago: Strong and consistently positive NPV outcomes highlight the role of favourable market conditions and import substitution in driving investment viability.

Policy Relevant Results

1) High downside risk in Yukon due to energy price volatility
2) High probability of NPV in Trinidad and Tobago supports R&D incentive
3) Manitoulin Island's consistently negative NPV distribution suggests that policy efforts should prioritize energy infrastructure

POLICY AREA	RECOMMENDATION
Economic viability	Provide targeted financial incentives in feasible regions
Cost mitigation	Subsidize energy and improve logistics infrastructure
Risk management	Use Monte Carlo-based risk-adjusted metrics for decisions
Regional strategy	Adopt place-based policies tailored to local conditions
Food security & climate	Integrate vertical farming into resilience and adaptation plans

Takeaway message: ***Hydroponic vertical farming is not a universal solution—but in the right economic environment, it can be a financially viable tool for food system resilience. This means one-size-fits-all agricultural policy is ineffective.***

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