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A Collaborative Decision Support System Framework for Vertical Farming Business Developments

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ABSTRACT

The emerging industry of vertical farming (VF) faces three key challenges: standardisation, environmental sustainability, and profitability. High failure rates are costly and can stem from premature business decisions about location choice, pricing strategy, system design, and other critical issues. Improving knowledge transfer and developing adaptable economic analysis for VF is necessary for profitable business models to satisfy investors and policy makers. A review of current horticultural software identifies a need for a decision support system (DSS) that facilitates risk-empowered business planning for vertical farmers. Data from the literature alongside lessons learned from industry practitioners are centralised in the proposed DSS, using imprecise data techniques to accommodate for partial information. The DSS evaluates business sustainability using financial risk assessment. This is necessary for complex/new sectors such as VF with scarce data.

KEYWORDS

Artificial Intelligence, Business Sustainability, Decision Support, Imprecise Data, Risk Assessment, Vertical Farming

INTRODUCTION

Background

Feeding a predicted 9.8 billion people by 2050 (UN DESA, 2017) on a planet stressed by climate change, water scarcity, soil degradation, ageing rural populations, and rising levels of urbanisation, will require constant innovation in resilient farming methods to increase food production by 25%-70% (Hunter et al., 2017). Key problems with traditional agricultural methods include (i) its use of 70% of the world's freshwater, 60% of which is wasted due to inefficient irrigation (WWF, 2019), (ii) its loss and waste of an estimated 33% of all food (FAO, 2019), producing 8% of global greenhouse gas emissions (FAO, 2011), and (iii) food contamination accounting for 600 million people falling ill, 420,000 people dying and $95 billion annually in lost productivity (WHO, 2019). A relatively new concept in the field of urban agriculture (UA), vertical farming (VF), has arisen as a method to engage with the challenges by producing local, consistent quality and pesticide-free nutritious food all year round. VF is defined as the practice of hydroponically cultivating crops indoors in vertically stacked layers or inclined surfaces. Figure 1 delineates the concepts of UA, indoor farming and VF, and how these classifications may overlap.

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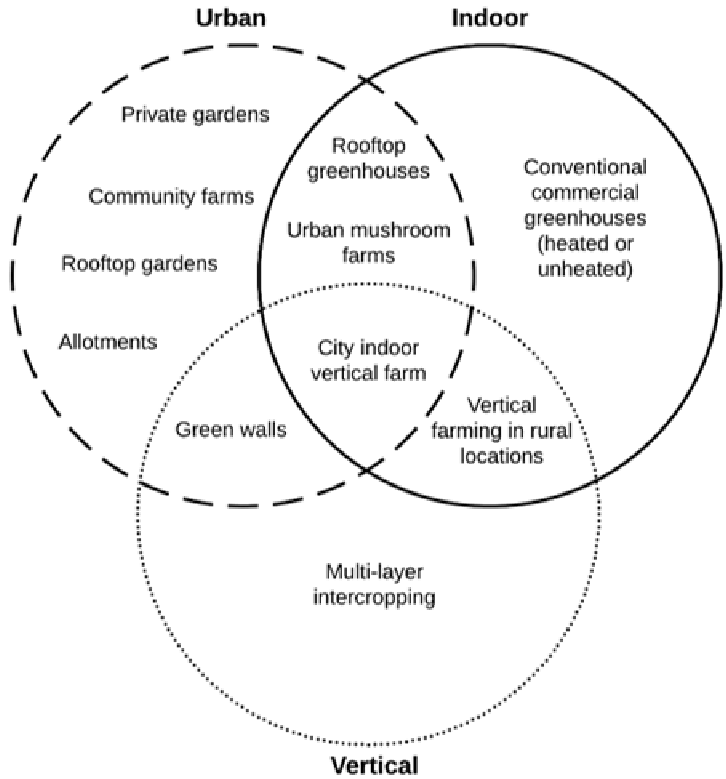
Figure 1. A Venn diagram to classify agriculture according to whether it is urban, indoor or vertical, or a combination. Adapted from (Breewood, 2019).



Modern vertical farms utilise indoor farming techniques to take advantage of controlled-environment agriculture (CEA) technology within structures such as shipping containers, warehouses, purpose-built plant factories, greenhouses on rooftops or the ground, facades and under-utilised basement spaces (Al-Kodmany, 2018; Baumont De Oliveira, 2020). Using CEA processes, environmental factors can be finely tuned for optimum growing conditions which are commonly called "crop growth recipes" (Meinen et al., 2018). Technically, it is possible to grow any crop vertically, but due to the high energy ratio required for edible matter, the most common crops grown are leafy greens, salads, herbs, microgreens, some vine crops, bio-pharma ingredients, and small fruits (Agrilyst, 2018; Agritecture & Autogrow, 2019; Hughes, 2018).

There are numerous benefits of VF when compared to conventional agricultural methods:

1. Minimising horizontal space requirements and increasing yield per unit area (Touliatos et al., 2016);
2. Reducing dependence on pesticides or herbicides (Marks, 2014);
3. Cutting water consumption by approximately 70%-95% (Barbosa et al., 2015; Bradley & Marulanda, 2001; Despommier, 2010);
4. Producing reliable year-round crop in soil-less environments independent of weather (Despommier, 2010);
5. Reducing the necessity for storage, transport and refrigeration by local production (Despommier, 2010);

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