5032M: Modern Industry Practice

Fields of the Future? A Sideways Look at Vertical Farming

In 2015, over 12% of the global land area was used for growing crops [1], with the world population expected to rise from 7.7 billion (mid 2019) [2] to almost 10 billion by 2050 [2]; we can only expect increased demand for food produce. Land-use conversion for agriculture is currently responsible for about one third of GHG emissions [3], the FAO[1] deem that the most effective methods of carbon sequestration[2] are afforestation and reforestation [3]. So, how can we increase food production, whilst also reclaiming land currently used for agriculture? One solution, which is growing in popularity, is a method known as *vertical farming*. This method involves growing plants in vertically stacked grow beds, under controlled indoor conditions. There are many advantages to this style of farming: considerably less land is required, crops can be grown all year round and soilless techniques use far less water; to name but a few. There are, however, also some serious disadvantages, a primary concern being the high level of energy used to operate these farms. In this essay, I will explore the pros and cons of vertical farming and examine some of the techniques used in vertical farming today.

The idea of vertical farming is not new, in fact, the idea of tiered irrigation systems can be seen as far back as 600BC, in the hanging gardens of Babylonia [4]. The contemporary use of the term, however, describes a heavily controlled agricultural environment. Development of the modern idea of the vertical farm is often attributed to Dickson Despommier. In 2001, whilst teaching a medical ecology class, Despommier challenged his students to design a facility capable of feeding fifty thousand people [5]. The outcome of this venture was a thirty-story city-block, equipped with hydroponic and aeroponic growing facilities [5]. Over the intervening years, these ideas were developed and by 2011, a Singapore based company, Sky Greens, announced it would soon be operating the first commercial vertical farming facility [6]. For densely populated city-states like Singapore, vertical farms offer a sustainable alternative to imported goods.

To make indoor farming financially viable, the crop yield must be maximised, while net; energy, water and CO_2 usage must be kept to a minimum. One of the key issues faced by vertical farming companies is the cost of their energy bills. Compared with traditional heated greenhouses, vertical farms use an estimated fourteen times the energy per growing area annually [7] [8]. It has been estimated that 98% of the energy used is for lighting (68%) and air management (28%) [8]. For this reason, it is vitally important for farms to invest in highly efficient LED lighting systems. Companies like OSRAM and Samsung are already offering highly efficient (>75%) LEDs tailored for horticulture [9] [10]. However, the use of highly efficient LED lighting is not a one size fits all solution.

It has been suggested that a balance of natural and artificial could be more efficient depending on the location [11]. Allowing more natural light also reduces the thermal isolation of a farm; in very cold climates, this will increase the energy required for extra heating; conversely, in hot climates, extra energy will be required for cooling [11]. Thus, in extreme climates, a highly insulated building is preferable, whereas in more temperate climates, use of some natural light can be beneficial to energy efficiency [11]. This is just one example of why a farm's location must be a primary consideration for its design.

Although vertical farms require large amounts of energy to operate, they are incredibly water efficient. The FAO predicts a 50% increase in irrigated food production by 2050, however, the amount of fresh water drawn by agriculture can only increase by 10% [12]. It is therefore vital that agriculture practices become more water efficient. Here is where vertical farming shines; hydroponic growing methods are estimated to use 13 times less water than traditional farming methods [13], while

[1] FAO: Food and Agriculture Organisation of the United Nations

[2] Carbon sequestration: the process of capturing and storing atmospheric carbon dioxide.

aeroponic methods use 90% less water than hydroponics [14]. Migrating even a fraction of current food production to vertical farming facilities has the potential to reduce agricultural water use considerably.

Farming indoors brings many other advantages for sustainability and ecology. In 2019, the UK imported 80% of its food [15]. All this transport equates to a significant carbon footprint, not to mention the energy used for cooling or freezing produce in transit. With available farmland in the UK scarce [16], it is becoming increasingly important to find alternative farming methods. Concentrating food production into urbanised areas has the potential to reduce transport costs to a small fraction of those for imported goods. A situation where tomatoes no longer need to be flown from Spain; they can be grown next door to the distributor. Additionally, food produced this way will relieve pressure on existing farmland. If the effect is significant enough, it will become possible to allow natural ecosystems to return to previously farmed land. In this way, effective carbon sequestration can take place and assist the mitigation of climate change.

It seems likely that vertical farming is something we will see more of in the future. Today however, there are still many more technological and economic challenges to face, yet the rewards for overcoming them will be of great to mankind. At present, the energy demand of vertical farms threatens their financial viability but improvements in the efficiency of lighting and air management systems hold the potential to mitigate these issues. Hydroponic and aeroponic growing methods are highly water efficient. Making use of these methods as a partial substitute for traditional farming will help to alleviate the strain on global fresh water supplies. In addition, urban farming could allow reforestation of farmland as an effort to recapture atmospheric carbon-dioxide. Vertical farming may not be a comprehensive solution to the world's food production challenges, however, for land-scarce regions which rely heavily on imported produce; it provides a local alternative, which can be integrated into urban landscapes.

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