How Much Water Can We Save in Vertical Farming?

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***Abstract*—Over the years, Natural Resource Management has become a key factor in the sustainability of the world and the environment. One of the important requirement of the resource management is to provide sustainable food to the people. Many alternative agriculture approaches have been developed to meet that requirement. One of the popular approaches in the agriculture is Vertical Farming (VF). In this article, researches on the VF are compiled to analyze how much water could be saved compared to the traditional agricultural methods.**

***Index Terms*—Vertical Farming, Interdisciplinary Project, Water Conservation.**

I. Introduction

Changing environmental conditions like unusual weather, water shortages and the soil degradation is threatening the crop production. According to the study "How to Feed the World in 2050", in 2050, it is estimated that the world's population will grow to 9.3 billion and the urban population will almost be doubled from 3.6 billion. This estimated growth in the population requires to increase the crop yield per unit area and to decrease the resource consumption. In addition to the population increase, there is also risk to lose agricultural land through the expansion of the urban areas. Under these circumstances, increasing crop yield per unit became a vital part of the sustainable agriculture. That is the reason why VF is nowadays gathering momentum. By farming in controlled environments with different stack methods, VF decreases the pressure on the agricultural lands. [1], [2], [3]

II. Categories of Vertical Farming

In VF, there is two different categories in terms of positioning of the crop. These are horizontal growing platform and the vertical surfaces. Some of the most common systems are shown on the figure below

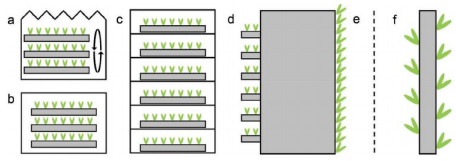

Fig. 1. a, b, c (multi-floor tower) and d (balcony) represent stacked horizontal systems. e (green wall) and f (Cylindrical growth) represent vertical growing surface.[3]

III. Techniques of Vertical Farming

A. Hydroponics

This is the VF technique where no soil is used to growth plant. The roots of the plants are submerged to nutritious liquids.

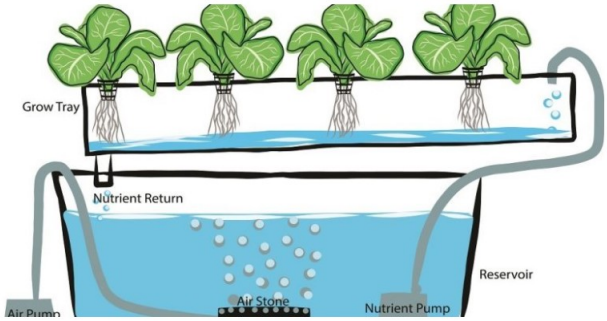

Fig. 2. Example of Hydroponics technique[4]

B. Auqaponics

According to Owen Mulhern, Aquaponics is defined as a type of farming system that combines aquaculture (farming of fish in water environment) with hydroponics (growing plants with water instead of soil) in a closed-loop system.[5]

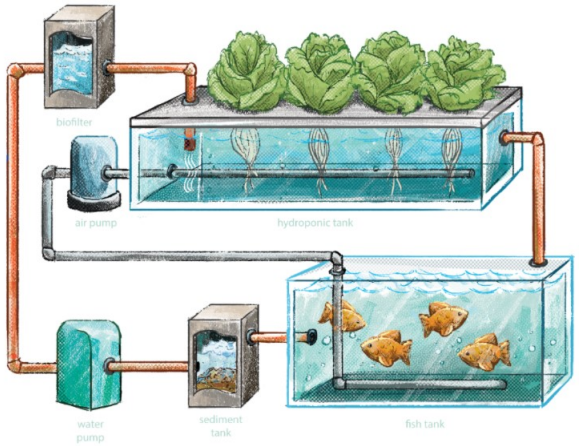

Fig. 3. Example of Auqaponics technique.[5]

C. Aeroponics

In this technique a nutritious liquid is sprayed or misted to the plants that are suspended in a chamber.

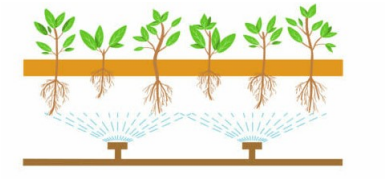

Fig. 4. Example of Aeroponics technique.[6]

D. Controlled-Environment Agriculture (CEA)

According to Jensen, this technique is described as a modified natural environment aimed to increase the crop yield.[7]. In VF soil-less techniques are often referred as CEA.

IV. Water Conservation in Vertical Farming

In Europe, it is estimated that the water used to produce food is 3000 liters/person/day.[8] It is possible that VF and other modern methods in agriculture would decrease this amount.

In 2015 Barbosa carried out a study on water consumption of lettuces, which are both in the hydroponics production and the conventional production in Arizona. According to the study, normalized water consumption by the yield, hydroponic production demands 13 ± 2.7 times less water compared to the conventional production. In lettuce production, $20 \pm 3.8 l/kg/year$ water is demanded in hydroponic, whereas $250 \pm 25 l/kg/year$ in conventional.[9]

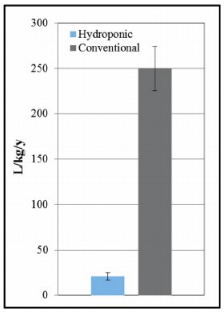

Fig. 5. Water consumption comparison between traditional production and hydroponics production.[9]

According to another study conducted by Despommier, CEA uses around 80% less water compared to the traditional farming.[10]

Plant Factory with Artificial Lighting (PFAL) is another area that VF concept is implemented. This concept is used both in mass production and indoor production. According to the Kozai, the water consumption for irrigation in a PFAL is 50 times less than the water consumption in a greenhouse, because about 95% of the transpired water vapor from plant leaves is condensed as liquid water at the cooling coil panel (evaporator) of the air conditioners, which is collected and returned to the nutrient solution tank after sterilization. Kozai stated in his book that there is also no need to wash the products that have been produced in a PFAL. Therefore, overall, the total water consumption for irrigation and washing of PFAL-grown vegetables can be reduced by 99% compared with that of greenhouse-grown vegetables. [2]

It is also stated that aeroponics and hydroponics systems are the best and the most efficient technique in the farming to decrease the water consumption. If these systems are used together as a closed loop system, water conservation rate can go up to 95%. [11]. According to the Besthorn, using greatly-advanced LED technology and close monitoring of every aspect of the food growth cycle, the Den Bosch project has cultivated nearly every imaginable crop, including beans, corn, cucumbers, tomatoes, and strawberries. While using 90% less water than a conventional farm, the Den Bosch vertical-farm has been able to achieve yields that are nearly three times greater than the average soil-based production system.[12]

V. Conclusion

According to the studies mentioned in this article, it is confirmed that the vertical farming is far more advanced than the traditional agriculture, when the aim is to save water. Vertical farms use less water to obtain increased yields in smaller production areas, even though their CAPEX costs are higher than the traditional farming.

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