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### Vertical Farming

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Recently, the UN Convention to Combat Decertification meeting in Argentina issued a warning that drought could parch close to 70% of the planet's soil by 2025. Drought is already affecting at least 41% of the planet, and environmental degradation has caused it to spike by 15 to 25% just since 1990.

As we know, there is a global crisis in food and water. Our civilization is being squeezed between advancing deserts and rising seas, so that there is less and less land for feeding the growing world population which at present is 6.8 billion. Currently food and livestock are grown on land equal in area to the size of South America. In 2050, with the forecast of population of 9 billion, we shall need additional land the size of Brazil. Deforestation is obviously not the solution as trees are the 'lungs' of the planet. Deforestation in the world is already a major contributor to atmospheric CO<sub>2</sub>.<sup>1</sup>

Since the 1980s, it has been realized that farming was stressing the land well beyond its capacity to support viable crops. Agrochemicals have destroyed the natural cycles of nutrient renewal that enable ecosystems to maintain themselves. A sustainable way of growing food is rapidly becoming an imperative.

As urbanization continues, we are building more and more skyscrapers with walls consisting of glass and the heat through them taken away by elaborate air conditioning. What a waste of energy over a small foot print of land! Greenhouses, stacked in a vertical high rise fashion to grow food, are a way to optimize energy consumption per unit of land.

There are many good reasons for growing crops indoors under vigorously controlled conditions:

- Food is grown in urban areas where it is eaten. There is no need to use fossil fuel to transport food from outlying areas.
- Unlike outdoor farming, indoor farming offers the freedom to choose location, temperature, moisture content, and soil composition.

<sup>1</sup> <http://rainforests.mongabay.com/0907.htm>, accessed April 17, 2011.

- There is no runoff water into the soil. In fact water may be obtained by recycling of the vast quantity of urban waste – so called black water. Again it is produced where it is needed.
- Growing food outdoors is subject to inclement climate conditions – droughts, floods, pestilence and unpredictable crop failures. Vast quantities of water and topsoil are lost in runoffs, creating ocean dead zones.
- Indoor farming offers protection from life-threatening parasite infections such as salmonella and cholera.

Already growing food indoors in greenhouses is commonplace. There are three techniques that have been used worldwide<sup>2</sup>:

1. Aeroponics. Plants are held in place so their roots dangle in air that is infused with water vapor and nutrients. This eliminates the need for soil. The amount of water needed can be up to 90% less than for outdoor growing. This is good for cultivating root crops such as potatoes and carrots.

2. Hydroponics. Plants are held in place so their roots lie in open troughs. Water with dissolved nutrients is continually circulated over them. This technique is soil free and needs up to 90% less water than outdoor cultivation. Today's greenhouses work on this principle. An example is Eurofresh Farms in Arizona, which produces large quantities of tomatoes, cucumbers and peppers year round. Spinach and berries are being cultivated similarly.

3. Drip Irrigation. Plants grow in troughs of lightweight, inert sheet material that can be reused for years. Small tubing on the surface rips nutrient-laden water precisely at the base of each stem. This eliminates the need for vast quantities of water used in traditional irrigation. This is good for cultivating grains like dwarf wheat and corn.

What is most significant is that by extending agriculture in the vertical direction, the yield over open land cultivation can be increased by a factor of 480. This calculation is based on four growing seasons, double stacking on each floor, double plant densities, and 30 floors.

Finally, for mitigation of climate change, it is best to leave the land in its natural grassy and woodland state where the vegetation will naturally absorb CO<sub>2</sub>. Example of such areas abound. A good example is the Demilitarized Zone (DMZ) between North and South Korea, which during the past 56 years has become a nature's paradise with a profusion of animal and plant species.

Although many planners worldwide – New York City, Los Angeles, Paris, Dubai, Abu Dhabi, Shanghai, and Beijing – have expressed interest, to date no prototype research and development vertical farms have been launched to address the two main questions of energy and water requirements, the urgency of global food and water scarcity notwithstanding.

*Gioietta Kuo has 40 years of research experience in nuclear physics, plasma and thermonuclear physics, and astrophysics, focusing primarily on energy challenges. In addition, she holds two patents in computer tomography image reconstruction in medical physics. Her work experience includes Siemens Medical Systems, the Princeton University Plasma Physics Laboratory, the Culham Laboratory of the United*

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<sup>2</sup> Additional information is available at [www.verticalfarm.com](http://www.verticalfarm.com)

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**POINTS FOR THE CLASSROOM** (send comments to [forum@futuretakes.org](mailto:forum@futuretakes.org) or post on FUTUREtakes blog):

- *In what ways will vertical farming impact available food choices? In what ways will it influence consumer behavior, considering (1) consumer preferences and (2) lifestyles that influence food choices – e.g., home-cooked meals, “fast food,” and restaurant meals,*
- *What are possible implications of vertical farming to existing farms, large (corporate) and small (family)?*
- *Identify other possible ways to increase food production per acre, per gallon of water, and/or per energy unit. Among these various approaches, which will be the most prevalent in your part of the world in 2018?*
- *How would you incorporate vertical farming into an integrated restoration program as envisioned by Storm Cunningham? (see synopses of Storm Cunningham’s programs in the Winter-Spring 2004 and Spring 2005 issues)*