URBAN ROOFTOP MICROFARMS

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1. Introduction

On the next visit to a local shopping center, take a good look at commercial rooftops . Imagine them covered with organic hydroponic microfarms providing substantial quantities of fresh vegetables and fruit for local food stores and restaurants. But do not, whatever you do, dismiss the idea as something too new and untested to be considered seriously. The concept was pioneered in Babylon about 2600 years ago. It has taken that long for humankind to both rediscover the technique, and to be reduced to it by overexploitive mining of natural resources such as soil nutrients and water.

In the view of many, the famed Hanging Gardens of Babylon were likely to have been the world's urban rooftop farming project. Little is reliably recorded about these gardens because most writings were hundreds of years after Babylon was destroyed, and these writings were often at least third or fourth hand. Indeed, that the Hanging Gardens of Babylon actually existed is not even certain.

John and Elizabeth Romer in their book *The Seven Wonders of the World* summed it up well: "Like the legends surrounding Alexander (The Great), these Hanging Gardens are the strangest, the most intangible, the most wonderful wonder of them all. Of all the Seven Wonders they are the one that everyone first names, but they are also the one that is most insubstantial."

No Babylonian record of the Hanging Gardens has been found in extant clay tablets, the recording media of the time. Notwithstanding, the story of rooftop gardens persists.

The most romantic (and perhaps most likely) story is that of the Assyrian King Nebuchadrezzar II (also spelled Nebuchadnezzar). He reigned over Babylonia (now southern Iraq) nearly 600 years before the birth of Christ. A number of stories suggest he built the Hanging Gardens of Babylon (the capital city) to please his Medean wife, Amytis. She was from the mountains, and pined for them in the hot, dry plains next to the Euphrates River, close to where the Iraqi city of Baghdad now stands.

Nebuchadrezzar, so the story goes, created a building to resemble a mountain slope, down which trees and other plants were raised on terraces. A bucket pump inside the building brought water for streams down the terraces. Administrative offices and store rooms were underneath.

No certain traces have been found of these Hanging Gardens, but in the late 1800s a German archaeologist, Robert Koldeway, did find an unusual series of foundation chambers and vaults in what had been the northeastern corner of King Nebuchadrezzar's palace at Babylon. Koldeway believed he had found the remains of the Hanging Gardens.

He and others working from the sparse records from more than 2000 years ago, have estimated that the arched vaults were probably about 23 m (75 ft) high, and covered a square with sides of about 120 m (400 ft).

Because stone was rare in Babylonia, the construction was likely to be bricks made of mud and straw. The rooftop microfarm they supported was probably waterproofed with bitumen, so that irrigation and pond water could not destroy the sun-baked bricks underneath.

The early Greek historian Diodorus Siculus, drawing on the works of others written several hundred years before, reported that the terraces were piled with fertile earth, and grew an abundance of trees.

Babylon's urban citizens were well versed in the growing of vegetables and fruit under irrigation, and often had fish ponds next their homes. Therefore, it can be argued that if they did exist the Hanging Gardens of Babylon could have been a source of fresh fruit and vegetables and fish and a visual pleasure for Queen Amitys. No doubt water plants for food could have been grown in ponds and in water channels made from the top to bottom tiers.

If this was so, then the Hanging Gardens of Babylon were also the world's first aquaponics— the raising of food plants and food fish in the same water where fish excreta is the organic source of nutrients for the plants.

The next serious rooftop microfarmers were probably the Aztecs, although we know this only from the observations of the Spanish conquistadores, who marvelled at highly productive chinampas and other sophisticated urban agriculture in which waste management was a key element before they laid waste to it..

Although, the details of Babylonian and Aztec urban farming efforts have been lost,

rooftop microfarming is now more than an embryonic reality in North America, Europe, and Asia.

2. Microfarming–What Is It?

The term "microfarming" was coined by the author in the early 1980s after studying emerging food production systems in agribusiness in Asia and North America, and after making observations about such faiths as "Permaculture," "Ecofarming," and "Community Supported Agriculture." The new word was necessary to distinguish small-scale (often small scale) food production from large-scale food production ("macrofarming"). It is a term most appropriate for the food production that can take place in cities—or urban agriculture.

But, whereas much urban agriculture can be classified as microfarming, the definition goes well beyond towns and cities. It can include operations underground (in mines, or in shelters from natural disasters), at sea (in ships or islands of floating housing condominiums), undersea (in nuclear-powered submarines), and in space. As humankind reaches to the planets to explore and colonize, and then to the stars, perhaps microfarming in a spore form will be survival for our species and others.

Microfarming on urban rooftops, the focus of this report, is perhaps one of the first steps toward a new destiny.

However, microfarming is not new in concept. It has been practiced in various parts of the world for centuries as people have grown food in small spaces—such as around their homes or within enclosures within cities (particularly when under seige). During two world wars in Europe microfarming around homes with food gardens was the way to survival for many people. Often there was an integration of vegetables, fruit, and small animals—the latter feeding off wastes or specially grown fodder.

In Asia, microfarming around homes was, and still is, integrated with the cultivation of fish and the reuse of nutrient-rich fish pond or fish tank water for irrigation of plants in containers (see *Recycling of Livestock Excreta in Integrated Farming Systems*). There is evidence that such microfarming could have occurred in China as long as 3000 years ago—half a millenium before the Hanging Gardens of Babylon (see *Biotechnology in Rural Areas*).

Then there's the microfarming systems reported to have been widespread in Central and South America. These were well-integrated horticulture, aquaculture, and small animal husbandry in small spaces (see *Production of Valuable Microalgae and Aquatic Plants from Animal Waste*).

Therefore, microfarming has been a part of humankind's food security for a long time. Indeed, it could be well argued that the first farming that emerged was microfarming, because it probably occurred in small spaces around caves or dwellings.

Much of our macrofarming, on the other hand, is more of a creation of the nineteenth and twentieth centuries (see *Environmental Biotechnology: Socioeconomic Strategies*

for Sustainability).

The importance of microfarming never really declined in those parts of the world that were less affected by industrialization, especially the industrialization of food production in the gamut of activities in agribusiness, where the interdependent elements are the farm input sector, the farm output sector, and the farm services sector (which includes government).

Agribusiness was less able to make money from microfarming, so it was much less promoted. That is now changing, because industrial agribusiness is being revealed as being inadequate in the totality of world food security. Perhaps the first to really realize this were the Chinese. They looked at their recorded history and observable prehistory and saw clearly that the important fundamental was the shift of nutrients from the soil.

In macrofarming and its mining of the soil there tends to be a one-way ticket for nutrients; they mostly go from farm to city to sea. In microfarming there is a greater chance of the nutrients being given a return ticket, through recycling of organic wastes. Microfarming offers a more sustainable system of food production than the the world's macrofarming systems that have created unsustainability. These efforts are best based on organic waste management.

3. Why Organic Hydroponics?

Organic hydroponics is a relatively undeveloped technology that has the promise of significant benefit to humankind in the twenty-first century and beyond. To understand this contention we must first know about inorganic hydroponics. The word *hydroponics* is constructed of language roots that mean "working with water." The term was coined during the 1930s when scientists were studying nutrient deficiencies in crop plants. By juggling the balance of nutrients in water, scientists were able to demonstrate the varying nutritional needs of plants, and what crop plants looked like when they had nutrient deficiencies.

It did not take much of a mental leap to see that crop production systems could be developed based on hydroponics, and over 60 years a significant industrialization of plant crop production took place as a result. Hydroponic growing in structures offered agribusiness operators all-important controls that gave:

- Higher yields in less space
- Quicker growth
- Less risk of diseases and pests
- Elimination of weeding, and much of the use of harmful chemicals
- Improved quality of produce

But inherent in this improved control has been the use of inorganic nutrients made by fertilizer companies. A hydroponic grower has recipes created by chemists. Not so the organic hydroponic grower.

Organic hydroponic growers create their nutrients from organic wastes put through

worm farms, or by extracting nutrients from plants (especially comfrey). As a result there is a lack of precision in the nutrients obtained. Indeed, organically produced hydroponic nutrient mixes can be extremely variable, depending on the organic waste input. This is certainly so with the organic wastes from restaurants, which can vary with the season as well as the type of cooking (e.g., a Chinese restaurant's wastes will be significantly different from those of an Italian restaurant).

To best utilize these differing organic wastes in a hydroponic system, it is necessary to blend from diverse sources to obtain some basic standardization of organic input. It is also necessary to have a judicious input of minerals to assure the best balance of macronutrients and micronutrients available from an organic "brew" of nutrients (see *Recycling of Agro-Industrial Wastes through Cleaner Technology*). This is usually done by adding appropriate rock dusts with known macro or micro components.

Offer this blend to worms in a "farm" capable of being sprayed with water (which is recycled through the worm beds to pick up soluble nutrients as worms excrete them), and a viable nutrient solution for organic hydroponics is obtained. It may not be as precise as inorganic nutrient solutions made up from industrial fertilisers, but organic hydroponic solutions can be highly productive. The reasons why organic hydropnic nutrient solutions are not widely used are:

- They take more trouble to create, and it is much easier to make up inorganic solutions.
- They can provide variable results, whereas inorganic nutrient solutions have reliability.
- There has been little demand for organic hydroponic technology.

A worldwide desire to better utilize organic wastes within cities can be expected to change this. The flow of nutrients from farm to sea must be intercepted as much as possible, either to return the nutrients to soil, or to better utilize them within cities.

Probably the world's leading organic hydroponics researchers are New Zealand's horticultural scientists Dr. Lynette Morgan and her husband Simon Lennard. They have found that selected organic wastes from human food processing and from urban, domestic, and food-service sources, can be recycled well via vermiculture. They are now producing an organic nutrient solution that can be as good as inorganic hydroponic nutrients made from so-called "artificial fertilizers."

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Biographical Sketch

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