Exploring Urban Agriculture
A Hydroponic Food Production Facility

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Ball State University
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This project explores the possibility of urban agriculture. In the past two-hundred years, cities have grown by a factor twenty-five and projections for the 21st century place over seventy-five percent of the world’s population within metropolitan areas. Cities across the globe are becoming more immense: Mexico City has a population of over twenty-five million people, Asia has thirteen cities with populations over thirteen million and China has thirty-two cities with over one million people. Everyone agrees that the Earth population will continue to grow, and many suggest the planet may no longer be able to support such a large population. Two of the major issues facing world leaders are the lack of clean, potable water and not enough food to feed the population; twenty percent of the world population suffers from malnourishment. The Food and Agriculture Organization predicts that sixty-four countries will not be able to feed their populations in the first part of the 21st century. Lately, rural poverty and the inability to financially sustain a rural farm have forced a great migration into the cities. This project seeks to take advantage of the situation, providing an energy conservative agriculture that uses dense planting and significantly less water while providing a place for urban residents to live and work, growing food to support themselves and the local community.
Hydroponics is the growing of plants without soil. It has developed over the centuries in various ways, but did not reach scientific growth until the early 1800’s as advances in the field of chemistry were made. The development of plastics, mass production, and the advance of the computer and other equipment has allowed automation and lowered production costs. The process is still a young science, being used as a commercial entity for only the last fifty years.

Today, Hydroponics is a method of plant growth used in almost any climate. Recent estimates of hydroponics place over six-hundred acres within the United States. This is a fraction of the land used in other countries; Holland has over ten thousand acres, the United Kingdom has over four thousand acres, and Canada has over one thousand acres. This method of plant culture is very flexible and can be adapted for any number of different environments, even being attached to desalination plants to use ocean salt-water for the growth of food.
The greatest advantage to hydroponics is that it can be used in developing countries to provide “intensive food production in a limited area.” In locations with very little arable land or limited land availability, hydroponics provides a solution that requires far less land and does not rely on soil that may not be conducive to the growth of food. As an example, hydroponics may yield 150 tons per acre each year. Using traditional methods, a ten acre farm only produces two tons of tomatoes per year.

One key aspect of hydroponics is the use of a specifically tailored nutrient solution provided directly to plant roots. This method limits disease among crops, yields controlled and stable plant nutrition, eliminates weeds, controls and minimizes the use of water, and increases lbs/year/plant by up to twenty-five percent. Another key advantage of hydroponics is the denser plant growth. Plant roots do not need to spread and compete for resources. Often, plants are maintained to grow vertically. In addition, because of controlled environments, a typical plant can provide three or four annual crops instead of just one provided by traditional agriculture. Overall, hydroponics acts as one possible solution to the problems facing traditional agriculture in the 21st century.
The project is an urban infill design; the primary function of which is to provide a suitable environment for hydroponic food production. The project also recognizes the need for urban planning and management as well as the growing urban low-income population, and disadvantaged communities. The response, therefore, is to take advantage of the opportunities of an urban site by provide a functional blend of commercial retail, industrial food production, and residential living. In addition, the core idea behind the function of the facility is that it will serve the community in which it exists. Therefore, the primary function, the hydroponic food production, is carried out by members of the community, ideally those who live in the residences provided within the project. In addition, food grown at the facility will be filtered into the local community by way of the commercial retail provided within the program. The result is neighborhood environment that begins to take responsibility for its own social and commercial growth.
## Facility Program

### Hydroponics Facility

- Production Greenhouse: 125,000 sqft
- Processing and Packaging: 5,000 sqft
- Equipment Storage: 10,000 sqft
- Chemical and Water Storage: 2,500 sqft
- Produce Storage: 1,000 sqft
- Locker Rooms: 1,000 sqft
- Shipping Office: 150 sqft
- Shipping and Receiving Area: 1,800 sqft

### Commercial Retail

- Rentable Space: 35,000 sqft
- Cafe Seating: 2,200 sqft
- Shipping and Receiving: 1,300 sqft
- Public Toilets: 1,000 sqft

### Building Operations

- Mechanical Room: 12,000 sqft

### Building Office

- Entry: 850 sqft
- Reception Area: 500 sqft
- Offices: 1,500 sqft
- Conference Rooms: 2,000 sqft
- Multi-Purpose Rooms: 3,000 sqft
- Gallery and Informational Area: 2,000 sqft
- Storage: 600 sqft
- Toilets: 900 sqft

### Residential

- Apartment Office: 1,500 sqft
- Residence Lounge: 1,700 sqft
- Apartment (each): 1,000 sqft

### Building Total Area

- 392,000 sqft
The project site is located within the city of Dayton, Ohio. Specifically, the site is located on the eastern edge of the downtown area. The surrounding area is historically an industrial neighborhood dominated by multi-story industrial warehouses and factories. In recent years, the city has made efforts to revitalize this depressed area. Identified as the Tech Town District, the city hopes to develop the area as a technology-oriented live/work/play district. The city plans to develop the neighborhood into a place of unique housing, high density technology employers, and diverse leisure options. Primary examples include the addition of 5/3 Field, a minor league baseball stadium for the Dayton Dragons, the development of the Entrepreneurs Center, a facility for developing small businesses, and numerous loft-style apartments.

The plan for the east side of Dayton as a Tech Neighborhood makes it a perfect choice for the location of this proposed facility. Conceptually, this project is about hi-tech industrialized production of food, as well as providing a unique living/working environment and including opportunities for commercial retail growth and leisure activity. In addition, the mix of residential and commercial facilities all placed within an industrial context agrees with the basic premise of the project as an industrial, residential, and commercial facility.
Several key design issues are apparent in the initial site analysis. Most important is that at the south edge of the site no existing buildings or other structure block direct sunlight for the majority of the day. This is ideal for providing maximum natural light exposure for growing plants.

The existing commercial layout provides the opportunity to connect two disconnected zones: the 2nd Street Market to the east and the storefront retailers several blocks to the west. Current pedestrian distribution provides natural locations for facility entrances and approaches.

The existing raised railway over 3rd street acts as a gateway into downtown when approaching from the east. This limits views upon approach, but it is important to note the first thing a visitor will see when passing under the bridge is the project site.
The existing scale (two to eight story structures) of the surrounding area suggests a multi-story facility is appropriate. To address the multiple scales, the project becomes a layered structure.

The ground level is scaled for the pedestrian, complete with a reference to the classical colonnade. This level is primarily zoned for commercial and retail activities.

The next levels are reserved for the food production and take on an industrial scale of open floor space and high ceilings.

The final upper levels are placed to the north end of the site and are the residential apartments. These units are scaled down in size and material. Both private and community roof-top spaces are provided for the occupants.

Finally, vertical circulation elements at the ends of the building provide anchor points for the varying elements of the project.

The city grid of Dayton, Ohio is rotated approximately 12 degrees. This rotated grid becomes a primary design concept of the building. Plant growth requires maximum light, and so the greenhouse part of the facility is rotated as a visual response to the needs of the plants. It is an effort to have the form reference the function of the space.
Building Perspectives
The first floor of the building contains the commercial retail facility, the building management offices, the apartment office and residence lounge, and the hydroponics chemical storage, locker rooms, and shipping and receiving.

The retail portion consists of storefront spaces each directly accessible from the street. In addition, interior rentable booths are available to operate as a public market. Visitors are encouraged to visit the vendors, stop at the cafe, and climb to the second floor gallery for informational displays and visual access to the working hydroponics facility.

The building office is accessible from the retail facility and the auto drop-off at the north end of the site. From here, visitors are greeted and led to the second floor for private presentations or educational experiences relating to hydroponic food production.

The residential apartments and hydroponics employee entrance is accessed by the drop-off and residential parking area to the north of the site. The common entrance provides the means for residents of the building and outside employees to easily access the locker rooms and the hydroponics area above.
SECOND FLOOR PLAN

HYDROPONIC PLANTING BEDS
The second floor of the building is primarily the hydroponic food production area. On this level, most of the food is grown, harvested, and prepared for distribution. In addition, this level has a small area accessible by the public for viewing the working hydroponic facility.

The greenhouse area is left open for the employees to adjust planting layout for the variety of plants and methods of hydroponic production. The primary growing area is placed to the south of the site for maximum exposure to direct sunlight. Supporting areas are placed to the north and open out to the greenhouse. Food is grown and harvested and then brought to processing rooms to be cleaned and wrapped before being sent below for storage or immediate distribution. Employees have access to an outdoor balcony for outside air.

To the north-west is the public gallery and viewing area. This space includes multi-purpose classrooms for educational or professional presentations, each with direct visible access to the greenhouse. Open spaces for informational and educational displays provide visitors an opportunity to learn more about the facility and its operation.
The third floor of the building provides more production area. This balcony overlooks the main greenhouse floor. In addition to the extra growing space, this floor contains a large open storage area to contain the materials necessary for hydroponic production. Finally, the floor is the location of the building’s primary mechanical room that services both the hydroponics greenhouse and the retail spaces on the first floor. As on the second floor, the third floor has outdoor balconies that are accessible by facility employees.

Above is the greenhouse structure. It is a steel spaceframe that supports a faceted glass roof. The roof contains drains to catch rainwater. The drains run along the inside of the roof structure and are carried to catch basins for use within the greenhouse. The structure also contains interior drains to catch condensation that may form on the glass.
COMMUNITY ROOFTOP SPACE
The residences are placed on the rotated grid. Each unit includes two bedrooms, a living room, kitchen and eating area, full bathroom, and utility room. In addition, the units include a small greenhouse for individual use. Each greenhouse opens onto a private balcony. All apartments are accessed from the first floor through the apartment office by elevator or stairway. The sixteen apartments are ideally leased to workers of the hydroponic facility. This creates a community atmosphere and helps to reduce expended energy for food production.
South Elevation

West Elevation