Design Strategies for Urban Agriculture in Dense Urban Areas

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Abstract. Urban agriculture provides economic, social, and cultural functions that improve human health and well-being for individuals and communities that reside in cities. However, with high land values and densely populated areas, available spaces for urban agricultural development are relatively rare. This research aims to explore feasible ways for residents that live in dense urban apartments to operate urban agriculture within the confines of a limited space. The design strategies for apartment farming will be summarized, which will provide opportunities for urban residents to grow fresh food, despite living in dense urban areas.

Keywords: Urban Agriculture, Apartment Farming, Dense Urban Areas.

1. Introduction
With increasing urbanization, land that was previously farmland has turned into metropolitan areas. Food production is distributed from human habitat, with very few residents having direct engagement with food production and land activities [1]. But with a growing eagerness to gain access to nature and fresh food, urban agriculture is becoming more popular. Community gardens have started to pop up in and around cities, which has provided opportunities for city dwellers to have access to freshly grown food. However, these types of opportunities are not available to everyone. Not all communities are equipped with community gardens, with most community garden plots only available to a small portion of residents that have been assigned the plots on an annual basis.

For many city dwellers, available ground-level gardens are usually out of reach, so how to grow their own food is a question that needs to be solved. Apartment farming provides urban residents with an opportunity to grow fresh food, even if they do not access to any land. Apartment farming is also a form of urban agriculture, because it is a creation for people that live in apartments and do not have backyard gardens or community plots. This concept is becoming popular with many urban residents choosing to grow edible plants even if they live in a small apartment without an outdoor space [2].

2. Opportunities
Apartment agriculture provides several opportunities for residents. The concept enables city dwellers to produce suitable and accessible fruits, vegetables, mushrooms, herbs, medicinal plants and other products. To integrate urban agriculture and high densely populated cities, the apartment farming concept could support a healthy lifestyle and provide people in cities with a good quality of life.
2.1. Food Security
The food production of apartment farming should not be underestimated, especially in neighborhoods or communities with limited markets or retail food stores nearby (food deserts). With the recent COVID-19 pandemic, some places saw the food supply chain disrupted from time to time. It is vital to enhance local food production at the community or household level. With apartment farming, vegetables and fruits are consumed directly by the producer, and it provides access to healthy and fresh food for households, regardless of where they live. It also improves food and nutritional security [3].

2.2. Human Health
First, apartment farming could provide a new healthy style for citizens. Urban agriculture in the home would provide easy day-to-day access to fresh vegetables, herbs and fruits, which would lead to enriched and more balanced diets by supplementing proteins, vitamins, and minerals [4]. Apart from the direct benefit of food production, it offers access to green space that is recognized to improve psychological health and it encourages physical activity. Urban residents can grow their own food and enjoy the green oasis among the concrete urban environment. It would enhance an urban living environment and create a green and more livable atmosphere.

2.3. Education
Nowadays, food production is separated from regular human habitats because most people live in big cities. Experience with growing food is non-existent for most city dwellers. With urban agriculture and apartment farming, people can gain new knowledge about cooking, nutrition, science, environment, and cultural sensitivity or understanding [5]. For children, the food production space could be a new form of education and somewhere that they can learn about food-related information and have hands-on experience. With agricultural practices, food is not just a commodity that comes from grocery stores, but it is a bridge to nature and agriculture.

3. Limitations

3.1. Space
First, space is the primary challenge for apartment farming. Unlike community garden plots or backyard gardens, plant containers could be placed on the ground, although space inside apartments are very limited. However, there are still variety of spaces and planting forms that could be used, as food is not only grown horizontally, but also vertically. This includes growing food on balconies, windowsills, grow tents, walled gardens, rooftops or a small hydroponic system. These are all considerations when considering where is the best place and the most efficient way to grow food in an apartment.

3.2. Light Insufficient
Other that considering space, when you are growing food you will also need sufficient light. However, indoor spaces in an apartment, often have limited natural sunlight as it is blocked by walls and other structures. The rooftop, the balcony and window sides will be the best choices for growing plants. Light-emitting diode (LED) lights could be used as a light supplement. Both the amount of light and the best time of the day to have the lights on can be easily controlled. Vegetables that produce fruit, such as tomatoes, peppers or cucumbers require much more direct light than herbs, root vegetables or salad greens. Thus, in an apartment space, the type of edible plants should be carefully chosen based on light availability.

3.3. High Aesthetic Requirement
For apartment farming, because planting areas are very close to a dweller’s living space, the aesthetics of the surrounding environment is very important. From most people’s perspective, the landscape of
Agricultural land is messy and monotonous, with many people preferring to grow ornamental plants to decorate homes than grow vegetables. So, this form of apartment farming should be well designed to meet the basic aesthetic needs and desires.

4. Approach
This research investigates the practices of existing apartment farming programs through the exploration of a number case studies. This will enable the study to summarize a feasible design strategy for a dense urban area. The author will look at urban agricultural cases related to key words such as apartment agriculture, in-building agriculture and home-grown agriculture.

The first case that will be examined is called Window Farm. It is a program founded in Brooklyn, New York, which provides opportunities for city dwellers to grow fresh food in their own homes. A window farm is an indoor hydroponic urban gardening system and installed vertically by the window. It functions all year around and can grow greens, herbs, and small vegetables [6]. The window farm system is quite simple. It is comprised of upside down recycled plastic bottles where plants are grown, and an air pump is used to circulate liquid nutrients. Water and liquid nutrients are pumped from the bottom water reservoir up to the top plant bottle using a lift system. Water then trickles down from one bottle to another, which gets to the roots of the plants. The Window Farms website provides instructions on how to put together the system, and the materials cost about $30 [7]. With an affordable price, simple equipment and a high-quality aesthetic, the Window Farm system provides a suitable example for vertical and hydroponic farming for apartment farming.

![Figure 1. Window Farm. Photo by Julia Makarova [7].](image1)

Grove is also a suitable edible garden system, that is a good example of indoor apartment farming. Designed and built by engineers from MIT, the Grove ecosystem combines plants and fish aquarium components together to create a symbiosis, called aquaponics. This system provides essential nutrients to grow vegetables, herbs, and small fruits [8]. LED lighting is used in this system, with the plants not needing to be exposed to the sun. With the Grove system, an apartment’s sunlight is not a limitation to someone growing edible plans. The Grove system is a cabinet-sized vertical farm. The size is suitable for an apartment, and this well-designed garden would be a vibrant decoration for any indoor space.

![Figure 2. The Grove Ecosystem [8].](image2)
With limited ground spaces in dense urban areas, roof top gardens have become another opportunity for urban agriculture, which enables apartment residents to create outdoor farming and gardening spaces. Rooftop farming is not a new concept, especially in the United States (US) and Europe. If the soil is deep enough, vegetables and small fruits can be grown on rooftops. For example, Ryerson University's rooftop farm is located in downtown Toronto. This initiative hosts programs that engage Ryerson students, faculty and the public to participate in the metropolitan infrastructure. With only a quarter of an acre, it delivers about 10,000 pounds of produce annually. In addition to food production, a rooftop garden could also provide distinct social values. A team called Rooftop Republic in Hong Kong is devoted to delivering a high-quality farm set-up and management services. This team engages with the community through interactive events and workshops [9]. Since it was founded in 2015, more than 60 small farms been built, and more than 5000 educational events been held regarding organic farming and sustainable living.

5. Discussion

Based on an exploration of case studies to grow edible plants, several approaches are identified for urban agriculture that can be utilized in dense urban areas. The vital component of this study is to determine how to make full use of the available space, including vertical systems and rooftop spaces. The design strategies for urban agriculture in dense urban areas are summarized below.

5.1. Indoor Space

To conduct urban agriculture inside an apartment, sun light and usable indoor space should be considered. If the sunlight is sufficient, and there is enough space, such as a balcony or patio, regular containers with soil would work. However, in an apartment with limited space and sunlight, vertical farming and a small growing kit is a feasible option. Thanks to new technologies, hydroponic systems, LED lights, and even some growing kits can be controlled by mobile applications. The size and form of growing kits are various. Some can be placed on a desk or on the floor, with others hanging on the wall or on the windows. Some can even be combined with furniture. People can make full use of their apartment space with these growing kits, making it easier to successfully to maintain a small-scale farm in an apartment. For example, the GroFast system is a small-scale indoor farm kit. In just seven days, microgreens can be grown and enjoyed. The AeroGarden Farm Plus is equipped with a hydroponic system and LED lights, so it does not rely on sunlight. Plantone is equipped with automatic watering and adjustable lighting, and is controlled by a smartphone application. This mini farm can grow five different species of plants at a time [10]. All of these indoor growing kits, aside from the food production, are well-designed growing kits that are decorative, and can add more green space and meet aesthetic needs.

5.2. Outdoor Space

Even though outdoor space is limited in dense urban areas, there are still some forms of urban agriculture that enables anyone to grow plants outdoors. With easy access and sufficient sunlight, a rooftop garden is the most common form of outdoor farming. Some communities replace ornamental
plants with edible plants in public green spaces, which is also called an urban food forest. They grow plants such as pecans, cherries, prunus, and blueberries, for the public to participate in the growing process and then harvest. Growing food outdoors requires good management and supportive policies and initiatives from local governments and other community lead organizations. These organizations will need to manage planting plots and hold food and planting related activities. By growing food and having outdoor activities, urban agriculture could bind the neighborhood together, enhance community engagement and cohesion, in order to create social values for the community.

6. Conclusions
Previous research has been determined that people can grow their own food in dense urban areas and in limited spaces such as apartments. Although this approach maybe not highly productive or efficient, it is a good way to introduce agriculture to our daily lives. City dwellers can enjoy fresh food that they have grown themselves, while at the same time, they can get in touch with nature, despite living in a concrete urban environment. This helps them to improve their quality of life and gain a healthy lifestyle.

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