Technological models for arranging an agricultural element in housing

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Abstract.
The article discusses the main technological models of the arrangement of an agricultural element in a modern urban residential environment, taking into account the peculiarities of cultivation technology, the location of the green element in the structure of the building and the design aspects of the arrangement of the agricultural element in each case.

Keywords: agriculture, urban farming, soil-based growing, soilless growing, linear growing, field-type growing
Urban farming as it is practiced today usually has very little in common with what would be associated with traditional farming in earlier eras. In the urban farms that exist around the world today, several methods of growing crops are practised, either in rooftop greenhouses or inside buildings. Usually, this process is independent of weather conditions or seasons, and harvesting is possible several times a year. The plant is grown without sunlight and soil, and with much less water than with traditional methods, which is very important given current trends in water conservation. However, there is often a traditional agrarian element in the structure of the building, the main role of which is more psychological and recreational than industrial. The process is less technologically advanced, but it includes all the additional engineering measures for the convenience of residents.

At the moment, there are two main technologies for arranging an agricultural element in the structure of a building [1]: soil-based growing or soilless growing (Fig. 1).

Figure 1

Technologies for the arrangement of an agricultural element in the building structure: 1. Soil-based growing. 2. Soilless growing.
The first one can vary in terms of the amount of earth mass used and can look like a classic farm located on a plaza or in other specially designated areas [2]. This technology involves growing plants in open ground or in containers. Containers and cloth pots are used to grow plants that will most likely need to be moved at some point. Growing in the field involves preparing the land and making beds, fertilising and irrigating. Additionally, the use of different types of soil is important.

Although open ground is the best growing environment, soilless cultivation saves water, soil and requires fewer pesticides, which increase the risk of soil contamination [1,3].

*Field-type growing* is a type of agriculture that involves the use of large indivisible areas with open ground for growing various crops. The most common are Traditional growing and Roof growing (Fig. 2).

![Figure 2](image)

*Figure 2*  
Field-type growing: 1. Traditional growing; 2. Roof growing

*Traditional growing* in the structure of multi-storey housing is an agricultural element in the form of a specially designated place for growing plant agriculture, for example, in the form of a common plaza (Fig. 3). Despite the fact that this is a primitive type of farming, its location within the building allows for an improved principle of operation. Placing agricultural production in residential buildings requires the use of a special irrigation system, which should be laid down at the design stage of the building. The disadvantage of this type of cultivation is the large amount of earth masses and the occasional presence of a certain number of people on them, which requires more powerful load-bearing structures, the use of the right materials and
restrictive elements to prevent the destruction of structures due to plant growth. Among all the possible options for the agricultural element, this one has the greatest impact in terms of recreation and greening of the environment, ensuring privacy and creating the impression of a suburban environment [4].

Figure 3
Traditional field growing in the backyards of residential buildings, Aspern, Vien

Roof growing in the structure of multi-storey housing is an agricultural element in the form of a specially arranged place on the external horizontal enclosing structures (Fig. 4).

Figure 4
An urban farm on the roof of a residential building in Chicago, USA, which has been in operation for over 30 years [5]
There are two possible options for this type of farm: distribution of plots among residents with individual access, or common use with conditional boundaries. This type of farm does not require special equipment, but in order to simplify operation, it is recommended to provide for automatic irrigation systems, distribution, water and sewage disposal to the agricultural element, premises for seedlings, workshops, etc. at the design stage [5]. The most common use of roof farming together with hydroponics for commercial purposes is in the field of roof gardening [6].

**Linear growing** is a type of agriculture where crops are grown in a curved or straight line (Fig. 5). It is usually grown on open ground using automated irrigation systems.

An apartment plot is an arrangement of an agricultural element with a strip of soil on the surface of the ground, terrace, or roof. Usually, it is located in the apartment space, but due to certain design and technical factors, it can be placed in other places (Fig. 6). First of all, this use of landscaping, in particular agricultural landscaping, creates segregation between private and semi-private space, serves as a psychological barrier that reduces the likelihood of strangers entering the semi-private space of the residential complex. Such an agricultural element is equipped with water supply and drainage, but unlike a roof or traditional farm, the irrigation system is manual. The disadvantage of such a farm is the direct connection of plants with the street or transit routes.
Box growing is the arrangement of an agricultural element in the structure of multistorey housing, which partially solves the problem of a large mass of landscaping by using cells (Fig. 7). They allow to reduce the total mass of land by eliminating unnecessary volumes and clearly distribute the load from them. This makes it possible to reinforce only the necessary parts of the structure. Such stationary cells are envisaged as a design solution, and they are complemented by all the necessary measures to simplify the operation by residents: water supply, sewerage, and water drainage. The main disadvantage is the clearly limited space for growing plants. This significantly reduces the variety of plants available for cultivation.
Balconies spots are extensions or recesses of balconies, galleries, terraces where space for agricultural production is arranged. It is similar to box growing, but the plant cells are larger and more complex in shape, and are part of the building (Fig. 8). They can be either external or located in the structure. This allows only certain structures or parts of them to bear the load. It serves as a visual and noise barrier between the balconies of the apartments and the street. The disadvantage is additional construction costs and a complex drainage and drainage system that affects the appearance of the building.

Green wall growing in the structure of multi-storey housing is an agricultural element in the form of multi-
layered horizontal structures placed one above the other, creating the impression of vertical green walls, for example, a number of special flowerpots on balconies or galleries (Fig. 9). Such facilities are used for individual use (when placed on external enclosing structures) and for common use by residents on the floor (in the interior space). For the functioning of such elements, inventory rooms with gardening accessories are required, which are located on the floor or in the apartments.

This method is best combined with aquaponics.

Soilless growing is a method of growing crops in nutrient-rich mineral solutions (Fig. 10). The composition of the mineral solutions depends on the crop being grown. Soilless cultivation methods include aeroponics and its subtypes and
fertiliser solutions. One of the advantages of soilless cultivation is that, unlike soil-based farming, where farmers have to use fertilisers to increase yields and pesticides to protect against weeds and pests, crops grown in a soilless environment are more protected. The biggest advantage of soilless cultivation is the yield, which is significantly higher due to intensive methods and the possibility of continuous, yearround production. However, plants grown in soilless environments can be susceptible to pathogen attack due to high humidity levels and are also more prone to rapid death due to their lower buffering capacity [1].

**Figure 10**  

*Hydroponic is the first type of soilless farming.* Plants are cultivated in a tank with a nutrient-rich water solution that flows through a tube system (Fig. 11). These tubes have openings in which the plants are grown at an optimal distance from each other. The water circulates and is distributed through the tubes in a closed system that sows out the waste water. The water lost from the plants is recaptured, treated and fed back into the system. Also, the roots grow in one direction and do not take up much space, because the plant does not need to find water on its own. This method is used mainly for growing salad greens and salads, herbs and strawberries [7]. In a residential structure, hydroponics is considered to be simple, but expensive. These are usually balconies, loggias, and cascading terraces. Such an agricultural element is located on a floor-by-floor basis so that the system is integrated and can be operated properly. Water is supplied from the apartments or from a separately located common water box.
Aquaponics can be metaphorically described as a "tomato fish". It is a mixture of hydroponics and aquaculture, or fish farming (Fig. 12).

Aquaponics works on the same principle as hydroponics. But instead of tanks filled with a nutrient-rich solution, they are filled with fish. This water, including fish excrement, is used to provide nutrients for the plants, and the fish themselves feed on these plants. The combination of tilapia and tomatoes has proved successful. At the heart of the high-tech farm is an independent regulatory system that analyses and effectively controls all aquaponics and hydroponics systems, allowing the production of fish,
vegetables, herbs and fruits with only a small impact on resources [8]. In residential structures, it is only possible with medium-rise buildings, where the agricultural element is separately located and moved outside the apartments, as the smell of fish negatively affects the quality of the accommodation. In addition, fish care is necessary for the proper functioning of aquaponics.

Aeroponic - involves the use of sprayers, atomisers, or other devices to create a fine mist of solution to deliver nutrients to plant roots (Fig. 13). Aeroponic systems, which provide a macro- and micro-environment suitable for maintaining a reliable, permanent air culture, are usually closed. The size of the water droplet is crucial for maintaining aeroponic growth. A water droplet that is too large means less oxygen is available to the root system. Water droplets that are too small, such as those generated by an ultrasonic mister, produce excessive root hair without developing a lateral root system for sustainable growth in an aeroponic system. This requires maintenance and can lead to component failure. Another disadvantage of metal sprayers is that the plant's limited access to water causes the plant to lose turgor and wither [9]. In the structure of housing, it can only be in the form of a third-party commercial farm located on the roof or terrace. The technology is cost-effective, but requires high initial costs and constant monitoring. It also requires additional communications segregated from residential ones.

Figure 13
Left Inside look at an aerial watering system. Right Aeroponic tower [9]

References:
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