

# Urban agriculture as the main vector of development of the modern city

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**Abstract**—Nowadays, urbanization involves a symbiosis of architecture, nature and agricultural activities of a person. The inclusion of agricultural facilities in the structure of the city becomes a topical task of architects. In this case, a necessary condition is to use modern achievements in the field of technical equipment of buildings and structures, corresponding to the possibilities of plant's growth and life. Well-coordinated work of specialists in various fields as biology, chemistry, sociology, ecology, construction and architecture will allow to create modern complexes in which plant cultivation will be closest to the natural conditions and allow people to live in a comfortable, environmentally friendly world. Recommendations on urban planning, technical and constructive possibilities of including agricultural objects in the structure of the city and buildings will probable help to expand and increase the importance of this sector of the economy. Urbanization and compaction of urban areas increase the need for citizens to communicate with wildlife and also with plants. Using intellectual systems in the field of agriculture, it is possible to create settlements that, like living organisms, could adapt and rearrange, change their design parameters in accordance with human need and changing environmental conditions, while remaining in harmony with nature. Urban agriculture can make an important contribution to ensuring household food security, especially in times of crisis or food shortages. Consumers, especially residents of low-income cities, as a result of gaining access to fresh products in a wider range and at lower prices.

**Keywords**—*architecture, buildings, agriculture, urbanization, plants.*

## I. INTRODUCTION

Urban agriculture assumes a symbiosis of architecture and nature. A person, based on the process of cognition of the nature laws, can master new laws of morphogenesis, analyzing the constructive systems of living organisms, studying the principles of saving material, energy and ensuring the reliability of life activity. Using intellectual systems in the field of agriculture, it is possible to create settlements that, like living organisms, could adapt and rearrange, change their design parameters in accordance with human need and changing environmental conditions, while remaining in harmony with nature. The use of the experience of nature in the creation of modern structures can be the subject of study of this promising direction, involving the union of several professions, whose works should go in one direction - the study of the laws of nature. The basic principle here is not to destroy the environment, but by

comprehending its laws to create a more comfortable environment for a person, formed in harmony with nature, without harming it. The principle of symbiosis here is basic.

## II. PROBLEMS OF URBANIZATION

Urbanization affects all areas of human life. According to UN, by 2050, from 70 to 80% of the world's population will live in large cities. People will work, relax, be born and die in artificial habitats. The task for the architect is to create a humane environment in which a person can comfortably coexist. To resolve this issue, it is necessary then all spheres of human activity are engaged in the created environment. Satisfying the physical, spiritual and moral needs of the individual is necessary too. At the same time, it is necessary to take into account the roots of a person's origin, gender and age. [1]

But the fundamental tenet of human life, the main and immutable requirements of existence, is food. Throughout the existence of humanity - the plants played the role of not only nutrition, but also the satisfaction of all the needs of human life. Plants were an integral attendant of human life.

Urbanization and compaction of urban areas increase the need for citizens to communicate with wildlife and also with plants. Considering the experience of modern design, we can give examples of the wide inclusion of winter gardens in public areas and private apartments. At the same time, the traditional experience of designing visors, curtains, self-adjusting transoms, lanterns and room orientations is undoubtedly important for creating optimal living conditions for plants. Modern telecommunications, and the third industrial revolution, allow us to receive and share knowledge, as well as offer new solutions, using existing international experience. [2]

Achievements of science prove that it is easy to meet the nutritional needs in the present. Genetic engineering, brings new varieties that are not afraid of climate change and harmful insects, as well as useful birds and animals. Chemists create solutions for plant nutrition, which do not need land resources. Chickens carry 3 eggs per day and grow only 26 days, gaining the weight of a full-fledged chicken that grew 126 days. In laboratories, artificial meat is created, as a result, very soon there will be no need to raise and kill animals. And the media convey to people the safety and importance of such an approach to agricultural activities. The consequences of such an introduction into the human genotype are not fully understood. We can accept it or

oppose it, but the development of science and technology continues and these processes allow us to solve many emerging issues, although it is possible that politics and economics are not immediately able to respond to such a rapid introduction of science into the human life industry.

Modern architecture and technical capabilities in combining efforts allow us to propose new solutions and approaches to the developing agrotechnical complex. [3]

### III. FOODSTUFF PROBLEMS

Over the past two decades, average world food prices have increased by 2.6 percent per year. If this trend continues, it will not only threaten the basic quality of life (since most of the income of people goes to buy food), but can lead our world to the starvation.

There are still problems of hunger and malnutrition, especially in developing countries, giving rise to political speculations and popular unrest. According to the United Nations World Food Program, there were highest food prices in 2008 which caused unrest in 48 countries, including developing countries such as Somalia and Yemen.

World food supply is not catching up with the growing population of the Earth. According to the Food and Agriculture Organization of the United Nations, food production should increase by 70 percent by 2050 to meet global food needs.

Agriculture “takes” 70 percent of the world's water consumption, which increases its value. According to the experts, half of the world's population will face water scarcity by 2030, in this regard we can conclude that traditional farming methods are in an unstable position.

In addition to the many years of malnutrition and widespread poverty in developing countries, inequalities in food prices have now affect industrialized countries. For example, in the United States, the high cost of fresh produce has led vulnerable populations to buy low-quality processed foods and low nutritional value with a high content of fat and sugar.

Agriculture remains one of the most vulnerable sectors when it comes to natural disasters. Climate change is increasingly causing extreme weather events that can damage the whole crop of the season.

Higher temperatures also lead to an “unchecked” spread of pests and diseases of agricultural crops, however, many countries are trying to reduce the use of chemical pesticides in order to reduce the impact on the environment. [4]

As a result, we see that in the future, conventional agriculture can become quite unstable in term of source of food production.

### IV. VERTICAL AGRICULTURE

The experience of foreign architects in transforming houses that change the orientation of the premises to obtain the most insolation, as well as cooling and development of solar energy — can be taken as a basis for shaping approaches to the organization of spaces for growing plants.

Vertical farming is a term coined by Dixon Dysfomer, which implies the practice of food production in vertical farms, closed structures such as warehouses and transport containers. These structures make it possible to provide a

controlled environment for growing crops in a hydroponic or aeroponic system. Electronic sensors ensure that the crop receives the right amount of light, nutrients and heat. [5]

Benefits include: independence from plowed land, year-round capacity, lower water consumption and improved predictability of crop numbers.

For example, AeroFarms is a 70,000 square foot vertical farm on a refurbished steelmaking plant in New Jersey, 95 percent less water consumed and 390 times more productive than a commercial field farm in the same square meters.

Growtainer manufactures easy-to-use 20 or 40-foot shipping containers designed as insulated hydroponic farms. The goal is to help people grow leafy vegetables in places where they will be eaten right away.

Vertical farms can help meet the needs of a growing population by offering an additional way to produce foods that do not have the same problems as in conventional agriculture.

The history of vertical agriculture began with the advent of the first cities. Huge gardens and arable fields were an element of landscapes of ancient cities [6]. One of the Seven Wonders of the World - Amicitis (or Semiramis) Hanging Gardens has become a well-known example of the use of the concept of vertical agriculture, which has come down to us from history. Medieval cities in Europe often had a rural economy, and they were called “cities” only because of their population, architecture, and adopted charters.

The industrial revolution and urbanization have accelerated the separation of functions between urban and rural workers, but such problems as the shortage of fertile land, the shortage of labor in the agricultural sector, and the increasing demand for food, which pose new challenges for the organization of agricultural production in large settlements have arisen [7].

In the modern conditions of the information and communication revolution, new solutions have appeared. The beginning of the 21st century is the modern stage of introducing breakthrough technologies (mobile Internet, artificial intelligence, cloud technologies, progressive robots, autonomous and semi-autonomous vehicles, the next generation gene industry, accumulation, energy storage and the use of renewable wind and solar energy, 3D printing, the appearance of materials new generation). Vertical agriculture is the cultivation of plants on an industrial scale in cities with full climate control, free of impurities and pesticides, and regardless of the season [4]. Vertical agriculture - growing mainly leaf plants inside buildings and on their vertical surfaces at different levels [2]. Thanks to new architectural and engineering solutions, information and communication technologies that provide automation of the agro-industrial complex, vertical agriculture is being designed and implemented in a number of developed countries.

It is possible to propose and describe a possible building model with an agricultural component for a large urbanized city. Of course, this model cannot be complete and final, since it requires active discussion with experts. However, nowadays, objective theoretical approaches and recommendations can be formulated.

For consideration, we propose a model for the inclusion of an agrotechnical complex in a modern MD.

MRC is a multifunctional residential complex, which includes residential premises for permanent or temporary stay, as well as non-residential premises, office, retail or service sector of the city. As a rule, these are large objects, which are cents of attraction and accents in the architecture of the city. Living in them is attractive for the majority of the population of the city, so the buildings are created with increased comfort and can afford additional functions as winter gardens, verandas and, as an option, agrotechnical complexes. These complexes can be offered as a variant of a public zone included in children's educational centers or by inclusion in a private apartment apartment space. For a more precise definition, select the geography of the middle band for application below recommendations.

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MFZ is a multifunctional residential complex, which includes residential premises for permanent or temporary stay, as well as non-residential premises, office, retail or service sector of the city. As a rule, these are large objects, which are cents of attraction and accents in the architecture of the city. Living in them is attractive for the majority of the population of the city, so the buildings are created with increased comfort and can afford additional functions as winter gardens, verandas and, as an option, agrotechnical complexes. These complexes can be offered as an option for a public zone included in children's educational centers or by inclusion in a private apartment apartment space. For a more precise definition, we will highlight the geography of the middle band for the application of the recommendations given below.

Urban planning:

- in any area (on the periphery or center), in a relatively free area, provided that the premises where the plants will grow are insulated sufficiently. In this regard, it is important to note that different plants relate differently to the sun.
- orientation to the cardinal points, can be consistent with the norms and recommendations of existing and widely used conservatories.

Space planning solutions:

- In public spaces - non-child use, it is advisable vertical development and the use of hydroponics, to maximize the yield. It is possible to use a two-light vertical space, which allows plants to receive daylight and sunlight.
- winter gardens and loggias - widely used in architecture, bay windows and glazed balconies - can be used to implement models of the device of small agro-technical complexes.

Technical and design solutions:

- achievements of recent years, prove great technical capabilities. Modern materials and design capabilities give us almost any architectural solutions. The most pressing issue in this case is approaches to saving and energy consumption.

## V. ADVANTAGES OF VERTICAL AGRICULTURE

Vertical farming produces more crops per square meter than traditional farming or greenhouses. Vertical farming also consumes less water, plants grow faster all year round - and not only at certain times of the year. Theoretically, such objects can also be built in any places. [8]

One of the firms producing equipment for vertical farming is Urban Crops. The concept of their invention lies in the fact that there is a large frame designed to hold trays with slow-moving conveyor belts of young plants under softly glowing blue and red LEDs. This system is automated. The equipment allows plants to eat light and nutrients during their entire growth cycle. Then they can be collected when the time comes. [9]

Each type of crop has a growth plan, adapted to its needs, for example, in nutrients and light. In addition, plants grow faster here than on an open farm. Another advantage of this method is compactness. Eight layers of plants can be folded in an area of just 30 square meters.

Growing plants indoors allows for full control over the resources that the crop needs. This allows plants to grow in a predictable and carefully controlled manner. LEDs, for example, can be turned on and off as desired because they do not emit much heat and can be brought closer to plants for optimal light consumption.

There are several basic models of closed agriculture that a vertical farmer can choose from: hydroponics - when plants are grown in a nutrient-rich pool of water - and aeroponics - when plant roots are periodically sprinkled with mist containing water and substances. In the latter case, less water is used, but more technical problems arise. There is also aquaponics, which is slightly different because it involves breeding fish, which helps to cultivate bacteria, which are then used to nourish the plants.

Vertical farms produce yields 390 times greater than with traditional farming methods. Using these farms, they harvest up to 30 harvests per year. Plants grow on pallets, tightly covered with a special reusable cloth. Plant seeds are poured onto the fabric. A mist containing water, nutrients and oxygen is fed into the tray under the fabric. The fabric is designed in such a way that it allows moisture to pass through to the seeds. The fabric serves as a barrier, preventing the mist from entering the surrounding space. Seeds germinate quickly and give roots. Plants, germinating, are tightly fixed by their root system in a special tissue. Gradually, they grow and form a powerful root system in the space under the tissue. From this space filled with mist, they consume water, oxygen and essential nutrients.

Thus, a special reusable fabric is not only a natural barrier that does not allow the fog to penetrate into the surrounding space, but also an excellent material to which the plant is attached with its roots and in which it is well rooted. After harvesting the fabric is reused after special treatment.

To illuminate the plants using artificial light. Therefore, an LED lamp is attached to each pallet on top. Each type of plant is illuminated by light with a specific spectrum, intensity and frequency. From pallets (about 10 and more) multi-storey tiers are formed. Racks with pallets can be placed in any indoor space, for example, in a high hangar or factory floor. [10]



Fig. 1. Vertical farm

Vertical farms consume 95% less water than traditional agriculture, and 40% less water than hydroponics. Along with the fog, nutrients, water and oxygen are supplied to the roots of the plants. The fog contains all the nutrients, micro and macronutrients necessary for the plant. As a result, the yield of vertical farms is 390 times greater than from a conventional agricultural field. And the whole farm is capable of producing up to 30 harvests per year. The entire system (fog supply, lighting, etc.) is remotely controlled by a computer. Intelligent control system, having accumulated the necessary analytical material, has the ability to predict future results - i.e. yield. It avoids the typical risks inherent in traditional farming.

#### VI. EXAMPLES OF ARCHITECTURAL PROJECTS USING VERTICAL AGRICULTURE

The project C. Favretto and A. Girardi (Studiomobile, 2009) was to create vertical skyscraper-style farms in Dubai that would act like massive tall glass buildings and use sea water to cool the building and water for plants.



Fig. 2. Project C. Favretto i A. Girardi vertical farm for Dubai

The authors attempted to recreate the water cycle in nature in this project to help solve the problem of lack of clean water, which is particularly relevant for drylands. The shape of the farm is similar to a plant with a trunk, providing the functions of the framework, people's access to the premises and the movement of water to the plants, and leaves arranged so as to close each other from overheating or open up for photosynthesis. Another project Oasis Tower (2009), should provide food to 40,000 people (Fig. 2).



Fig. 3. Project Oasis Tower, by Rahul Surin

It combines a zone for growing crops (lower) and a zone for people (upper). The design assumes a central core and three spirals, the use of wind turbines and solar panels.

These examples are quite original and interesting, both in terms of architecture and technologies of crop production. Many scientists agree that when designing human settlements, it will be necessary to combine modern developments in agriculture and eco-architecture [11]. Doing agriculture in cities led to the emergence of even a new approach in architecture - biomimetics, that is the method of creating objects based on ideas borrowed from surrounding living nature.

#### VII. FINDINGS

It is logical to assume that vertical agriculture will begin to develop in megalopolises and large cities, but in the future it may spread to rural areas.

Urban agriculture can make an important contribution to ensuring household food security, especially in times of crisis or food shortages. At the same time, the products are either consumed by the manufacturer, or sold in urban markets, for example, in the lately becoming increasingly popular farmers' markets, which operate in many cities on weekends. Since locally grown food is less in need of transportation and cooling, products are fresher and therefore more nutritious. Consumers, especially residents of low-income cities, as a result of gaining access to fresh products in a wider range and at lower prices.

#### VIII. THE DISCUSSION OF THE RESULTS

Vegetables grown on urban farms have a shorter production cycle; some of them can be harvested less than 60 days after planting. The productivity of garden plots is sometimes up to 15 times higher than in rural areas. An area of just one square meter can yield up to 20 kg of food per year.

City growers spend less on transport, packaging and storage, and can trade their products directly from trays on the streets and market stalls. They keep more of the proceeds, instead of paying the middleman. Urban agriculture provides employment and income for the poor, women and other socially vulnerable groups. Thanks to gardening for every hundred square meters of the gardening site, you can get one workplace in production, supplying the means of production, marketing and creation of surplus product in a chain from producer to consumer. However, in many countries in agricultural policy and urban planning the role of urban agriculture goes unnoticed. Often, manufacturers do not apply for permits. And since this sector

is officially rendered invisible, in many cities it is not covered by government support or supervision.

Urban agriculture is associated with health and environmental risks: pollution in the form of odors and noise, as well as inappropriate use of pesticides and untreated organic fertilizers that can leak into water sources. At the same time, with proper processing for reuse in agricultural production, wastewater might be ideal for urban agriculture.

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