

Possibilities of protected soil technologies as a factor in environmental protection in agricultural production

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Abstract. The article analyzes modern agricultural technologies and the growth of anthropogenic pressure on the environment. The characteristics of land availability in different regions of the planet are given. The problems of abandoned lands and farmland involved in turnover are revealed, including the legal component of these issues. The main directions in agriculture for growing crops in a controlled environment (greenhouse and vertical farming) are described. The possibility of implementing vertical farms is considered using the example of a strategic university project.

1 Introduction

Currently, due to the extensive use of agricultural lands, their fertility decreases every year and, accordingly, productivity falls.

It is possible to provide the population with fresh vegetables, fruits and herbs throughout the year through the use of protected soil technologies. It is necessary to develop processes for growing agricultural products in protected soil, especially in countries with cold climates and short daylight hours.

Growing vegetables, fruits, and herbs in protected soil (greenhouses) is one of the relevant, effective and developing areas of agriculture in many countries, including Russia. Scientific and technological progress contributes to the spread and improvement of greenhouse cultivation of agricultural plants, while it is necessary to think through varieties and hybrids, a system of watering, feeding and pollination of plants, maintaining and regulating the microclimate, creating optimal lighting, etc.

Not all states have the necessary amount of arable land (land) to ensure food security. Therefore, the agro-industrial complex (AIC) is faced with the task of developing and implementing innovative projects that make it possible to grow agricultural products in any environmental conditions. At the present stage, the development of crop production using vertical farms (protected soil) requires subsidies and support from the state.

Modern agro-industrial production has a huge impact on the environment, namely, soils are polluted and degraded, and the quality of water resources and atmospheric air

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deteriorates. The introduction of vertical farms will allow for more compact and concentrated production of agricultural products, and thereby reduce the load on natural systems.

2 Materials and methods

The article uses official reporting data on the state of agricultural land, regulatory and methodological documents regulating the cultivation of agricultural products in a controlled environment, as well as promising strategic documents of the Federal State Budgetary Educational Institution of Higher Education "State University for Land Management". Abstract-logical, statistical, monographic and historical methods were used.

3 Results and Discussion

According to the UN FAO, no more than about 5 billion hectares are suitable for agricultural production [15], another approximately 0.5 billion hectares could be additionally developed, but this is traditionally limited by climatic conditions, water shortages and the nature of the existing relief. Calculations carried out at the turn of the 20th-21st centuries show that with current agricultural technologies, the developed (used) area can provide food for 10, maximum 12 billion people [18]. And such a population size of the planet is predicted by the UN in just a few decades (Figure 1).

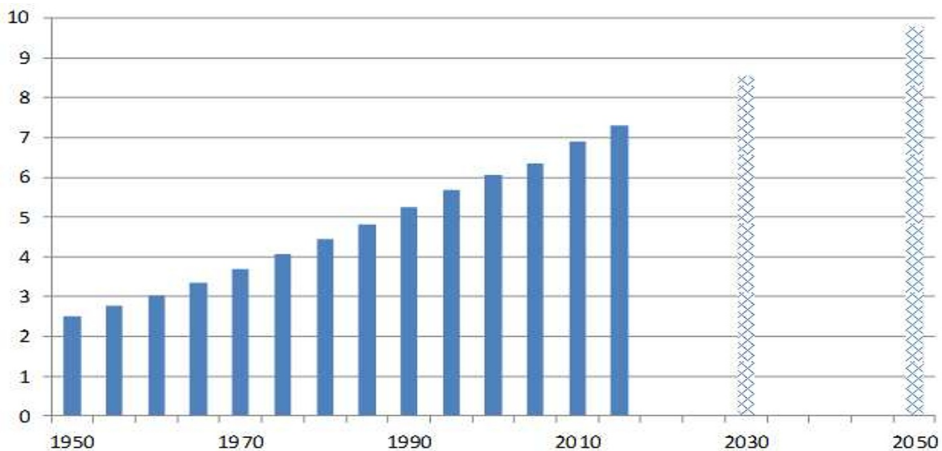


Fig. 1. World population in 1950-2050, in billion people (2030 and 2050 – forecast).

The current century is actually becoming the threshold of the final transition between different stages of agricultural land use in the history of civilization:

- At first, an increase in the planet's population led to the need to develop new lands (extensive stage).
- Then (until the turn of the 20th-21st centuries) the increasing population density required the extraction of a larger harvest from already developed areas (intensive stage).
- Finally, the current century (the stage of land resource shortage), when the growing shortage of good quality land is obvious and it cannot be fully compensated by the growth in productivity of traditional agricultural labor, the use of fertilizers, etc. Indeed, despite scientific discussions in agricultural economics, the law of diminishing returns of A. Turgot-T. Malthus (the law of diminishing productivity of inputs in agriculture)

still operates. Soviet science did not recognize this law - it was believed that “through developed technology, humanity has long since reduced the effect of the “law” of falling productivity to zero” [16]. Today, the understanding of this law has changed, and it has been determined that increasing the contribution to agricultural systems does not provide the desired increase in their productivity [11, 21]. Modern humanity can be attributed to a fundamentally new era, characterized by the fact that interstate competition is determined by the presence and condition of lands suitable for agricultural use [8, 10]. Therefore, it is necessary to move to completely new agricultural technologies.

The way things are in Russia with regard to land supply allows us to judge that, based on purely quantitative assessments, the ability to produce more agricultural products and promote additional volumes of them on the world market is more than promising (our country is very competitive in this regard). But, as noted above, about 500 million more hectares in the world could have been developed if not for the climate, lack of water and other conditions. Likewise, domestic farmland (their quality condition) is such that the emphasis in the revised edition of the Food Security Doctrine (2020) [6] on further reclamation and redevelopment of abandoned land was predetermined. It is enough to note that in Russia, land reclamation is less than 8% (at the same time, in other countries, for example, the USA, Germany, China, India, it is about 40%, and there are also huge areas of land that were previously developed, but which have recently 20-30 years ago they became abandoned - according to official data they amount to approximately 30 million hectares, but according to experts, such lands are 40-50 million hectares [23].

In order to bring abandoned land into circulation in 2021, the Federal Government of the Russian Federation developed and adopted a special state program [9], thanks to which it is planned to return about 13 million hectares of land to circulation by 2031 (Figure 2).

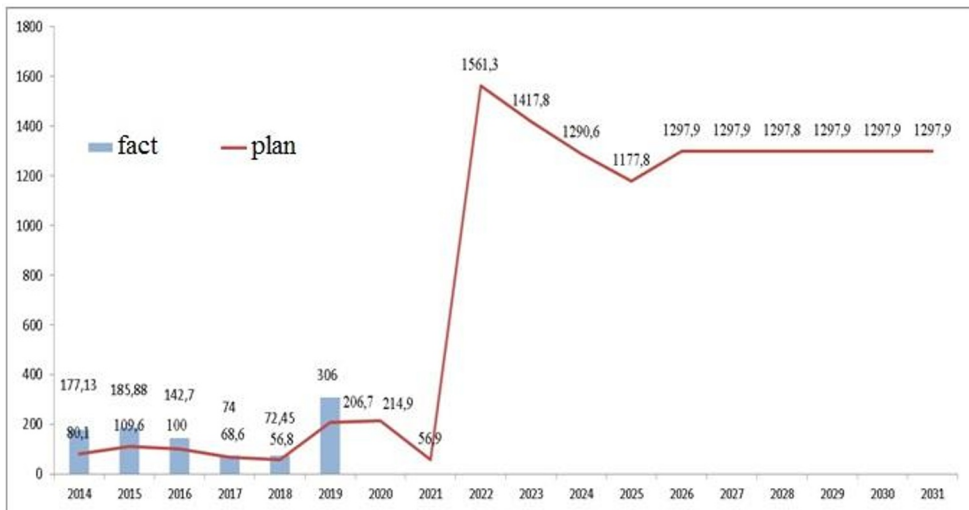


Fig. 2. Areas of abandoned land involved (to be involved) in economic turnover, in 2014-2031.

It should be noted that not so long ago in Russia there were two opposing approaches to solving the problem of abandoned agricultural land. In accordance with the first, abandoned and previously developed lands are subject to redevelopment and further ensuring their effective intended use [1-2, 7, 12, 24]. This approach is based on the principles of neoclassical economic theory, that is, in agricultural production, land is a unique, necessary and irreplaceable resource, and not all lands are suitable for agricultural purposes. In

addition, if, with the help of modern agricultural technologies, it is not possible to obtain benefits from growing agricultural crops on such lands (“marginal lands”), then they are still subject to reservation (conservation) for the agricultural industry; perhaps in the future, developed technologies will make it possible to use them to the fullest. The authors of this article support precisely this approach.

In the second approach, the main factor determining the purpose of land is only the current economic situation; accordingly, there is unregulated use and market turnover of these lands. That is, depending on supply and demand, the use of land is regulated, either the site is used for growing agricultural products, or for construction, or is not used at all [13, 20].

Assessing modern conditions, we can draw the obvious conclusion that the first approach is more correct. But at the same time, we note the existing difficulties in determining the effectiveness of financial, labor and other costs. Indeed, in the near future, high productivity of lands that are already in use can be achieved through, for example, the introduction of nutrients, the use of higher quality planting material and agricultural technologies. We also must not forget about the law of diminishing returns, which is a limiter, but most farmland in Russia is still very far from the “point of unjustified investment.” The benefits of redeveloping abandoned land include: the creation of new jobs, the development of lagging regions, which will subsequently lead to a multi-aspect effect and increased tax revenue.

Qualitative changes in the state of lands involved in agricultural production and those removed from it are constantly occurring and continue to occur. Unclaimed land shares are transferred by the courts to municipalities, which allocate them into plots, and this work has been carried out for more than 10 years. In 2025, it is planned to terminate the rights to the remaining unclaimed shares at a time; according to preliminary estimates, their area will be about 10-15 million hectares. (the area of redistributed farmland during the reforms of the 1990s was much smaller, and to a greater extent the issue was not the actual lands and plots, but the rights to them). In the future, the status of farmland will change; new land plots will be formed en masse, and along with the identification of abandoned lands and their development, these factors will have a direct impact on food security, and, accordingly, affect international trade in agricultural products.

According to the authors, land management must successfully resolve the issues raised and eliminate related problems. For example, when redeveloping abandoned lands, you can use materials and developments of land managers containing data about such lands and their condition; in case of litigation regarding the seizure of land, rely on information obtained during land management examinations; with the help of land management projects for the redevelopment of abandoned lands, taking into account their suitability for processing, market requirements, logistics and other factors. These measures will simplify the search for new rights holders for such lands, as well as organize their environmentally sound and economically beneficial use [4, 17].

Land management developments are also of decisive importance for other problems in modern Russian agricultural land use:

- Unclaimed shares are allocated to plots, and today such allocation is carried out without appropriate land management support, as a result of which there is no expected effect and difficulties arise in the massive formation of new plots from deprivatized farmland.
- The delineation of non-privatized land between different levels of public ownership, which has been happening for almost 25 years, will gain momentum.
- Large agricultural enterprises (for example, Miratorg, Prodimex, Rusagro, etc.) have concentrated farmland, which is assessed ambiguously by some agricultural economists [14, 19, 22-23], an objective assessment will be given when comparing indicators of rational land use and farming efficiency before and after such concentration.

The development of land management in Russia will depend on the adoption of the relevant law in a new edition. The variants of the bills differ in the following: 1) different understanding of the essence of land management (service or participation of society and the state in the management of the land fund; 2) different degrees of continuity in relation to the previous practice of Russian land management; 3) focusing on various problems in land use, primarily in agriculture.

When choosing the final approaches to this bill, it is important to take into account: firstly, the objective processes disclosed above in the system of agricultural land use (the inadequacy of land management provision, to some extent, became one of the reasons for the problems that have arisen there in recent years), 2) the rapid development of land legal acts at the federal level (both the adoption of completely new ones on the subject of regulation, and the adjustment of existing ones, adopted relatively recently [5]), 3) the use of promising digital technologies (which has been sufficiently developed for land management [3], 4) the need for significant intensification of agricultural land use and cultivation of products in regions with relatively unfavorable climatic conditions (which make up about 70% of the country's territory - Figure 3), in particular by placing vertical farms - one of the areas born in response to challenges associated with the shortage of land and resources is farming in a controlled environment.

Controlled environment agriculture (CEA) is an innovative approach to the production of agricultural products inside buildings or specially equipped structures using modern technologies and digital solutions. The main idea of CEA is to create optimal basic factors for plant growth and development: light, heat, water, air and nutrients, as well as protection from external conditions. Conventionally, CEA is divided into:

- Indoor agriculture (IA), in which plants are grown in enclosed spaces, such as greenhouses, containers, boxes, etc.
- Vertical farming (VF), which is a system of producing crop products in specially designed or adapted vertical structures.



Fig. 3. Favorable climatic conditions for agricultural production in various regions of Russia.

Such farms allow you to grow agricultural products using hydroponics, in any room. This is especially important for northern territories, characterized by low insolation, a short growing season, shorter daylight hours compared to the southern regions of the country, the

Sun is low above the horizon, which limits photosynthesis and plant growth. Summer is short, and the growing season of plants does not allow for the full growth of plants in agriculture.

The development of vertical farming can radically improve the situation with food security in the northern regions. The emergence of such farms will entail the creation of jobs and will save water resources. Vertical farms, compared to classical farming methods, consume 70–90% less water through the use of hydroponics or aeroponics. Another advantage is that their placement does not require farmland, which is very scarce in the north (and in general, they require minimal areas). Moreover, such farms can be equipped with artificial intelligence, which is capable of providing reliable and timely adjustment of lighting (turning on and off phyto-irradiators), supplying a nutrient solution, which minimizes the irrational use of required resources (Figure 4).



Fig. 4. One of the vertical farm options.

In world practice, vertical farming has become widespread in urban environments, which is why vertical farms are also called “city farms.” Their use can significantly reduce the time and distance of delivery of products to the consumer, increase crop yields per unit of area used due to a multi-level system of organizing space. They do not depend on seasonality, weather, climate and soil conditions. City farms also help improve the environmental sustainability of areas. Growing food on city farms is usually carried out in closed systems, which eliminates the use of pesticides and also reduces the amount of nutrients used. This significantly reduces the risk of environmental pollution and also allows you to obtain environmentally friendly products. Reduces water use (up to 95%), carbon footprint, food loss and waste.

Additionally, city farms can have positive social impacts. Participation in the growing process of crops on city farms helps build communities, strengthen social connections and raise awareness of healthy living and environmental sustainability. Finally, city farms provide opportunities for training and professional development in agriculture. They create new jobs and stimulate the development of knowledge and skills in the field of digital farming, agri-tech and sustainable agriculture.

According to the Moscow Innovation Agency, the global market for vertical farms will grow by more than 20% per year, and by 2030 will amount to \$33 billion. Venture investors have invested \$2 billion in them in 2021, which is double times more than in

2020. In Russia, according to experts, the growth in consumption of greens and organic products, low market saturation, the need for import substitution of a number of goods (about 49% of consumed greens are imported from abroad) will contribute to the growth of production on vertical farms by more than than 30% in the next eight years. As of 2022, there are 13 vertical farming companies operating in the capital.

At the Federal State Budgetary Educational Institution of Higher Education "State University of Land Management" on the territory of the Agro(bio)technopark "Chkalovsky" it is planned to implement the first stage of the strategic university project "Vertical Farms". This project provides for the involvement of students in the work in order to develop skills in working with vertical farms. Patented technologies for growing agricultural crops (berries, vegetables, herbs, etc.) using vertical racks with several tiers guarantee independence from sunlight and climatic conditions and allow you to obtain high yields all year round in any region of our planet.

The University Center for Innovation Projects, together with the Kuban Greenhouses company, developed a project for the construction of a greenhouse complex for growing crops (vegetables, fruits, herbs, seedlings, seedlings) regardless of the season. An area with a total area of 10 hectares is allocated for this project and work is currently underway to provide it technologically (electricity and gasification, increasing their capacity). As a result of the implementation of the project, additional opportunities will open up:

- Train future bachelors and masters in modern methods of horticulture and plant growing.
- Carry out research work in such areas as ecology, agriculture, soil science, crop production, etc..
- Grow environmentally friendly and always fresh agricultural products for the needs of the University.
- Demonstration of innovative developments of the University in agricultural branches of science.

To create and improve digital plant models that make it possible to characterize the main dependences of productivity (biological mass growth) on the influence of external factors, it is necessary to collect materials and analyze statistical data on the cultivation of various crops.

To date, the organizational, educational and methodological basis for the calculated data of the project has been developed. Technical documentation has been developed for submitting applications for Moscow tenders for City Farms projects. It is possible to attract labor resources to work on these protected ground sites.

The strategic project "Vertical Farms" will open a new profile "Protected Soil Engineer" in the following areas of training: Bachelor's degree 03/21/02 Land management and cadastres, 03/38/02 Management, 03/35/10 Landscape architecture; master's degree 03/21/03 Geodesy and remote sensing, 04/38/02 Management, 04/21/02 Land management and cadastres, 04/35/09 Landscape architecture.

4 Conclusion

Thus, the creation of vertical farms is directly related to the country's food security, makes it possible to increase productivity and provide the population with crop products. The project involves the Chkalovsky Agro(bio)technopark, which is a unique infrastructure complex that allows, among other things, the development and improvement of vertical farms. At the same time, the role of new scientific developments in the educational process is important, which creates systemic conditions for the harmonization of science, the educational process and personnel training.

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