



Review Article

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Role of green roofs in increasing the economic efficiency of the agricultural sector of the Russian economy. A review

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Green building; Green roof technology; Economic efficiency; Sustainable development; Organic farming; Energy efficiency.

Abstract:

The object of research is green roofs in the agricultural sector of the Russian economy. The purpose of this work is to analyze the green roofs and their function to mitigate the effects of climate change: floods caused by heavy rainfall or waves of unbearable heat, which are increasingly affecting residents of megacities. **Method.** The modern approach is used to analyze the green roofs and urban farms with current market indicators in Russian Federation and in the global market. The theoretical and methodological tools in this article are the principle of economic theory, which allow to substantiate ways to increase the economic efficiency of the agricultural sector of the economy of our country. Among the significant eco-directions, which implemented by Russian developers, the most popular are the economical work with water and the creation of additional recreational spaces on the rooftops. **Results.** This research examines the ecological sustainable technologies in the agricultural sector of the Russian economy and green marketing analysis of alternative organic farming.

1 Introduction

The dynamic effective development of agriculture largely depends on the provision of the industry with specialists of the required profile with high professional training and knowledge of the sectoral economics of the organization of planning management of agricultural production. The agro-industrial complex of Russia employs about 30% of all workers in the field of material production, more than a quarter of fixed assets are concentrated there.

The need for food is constantly increasing due to the complication of processes in the market, global urbanization and the gradual transition to new forms of economy. There are many discusses of carbon capture, storage and the utilization of CO₂ in the world [1–3]. Furthermore, it explains current green technologies and their future applications on environmental impact. Various opinions on the best way to achieve zero carbon emissions and on CO₂ applications and their economic impact are also discussed [4–7]. Economic efficiency, sustainable development and zero-carbon balance in building design by using green farms in the buildings are important part of any company of green market.

In these conditions, the problem of forming an effective economic mechanism in the agro-industrial complex is very relevant, as a set of methods and levers of economic influence on organizations in order to enhance the motivation of their production and investment with technologies of decreasing greenhouse gas emissions or with zero carbon print [8–12]. Domestic and foreign experience of economic relations shows that the agro-industrial complex is effectively regulated through cooperation and integration in production, the creation of various integrated organizational forms. Such processes contribute to the

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strengthening of production and economic ties, improvement of financial and economic relations between partners in the production cycle, while the tasks of integration are reduced to achieving consistency of economic interests each of the parties by determining the contribution of each participant to the final result. Environmental economic model of risk management and in the framework of the quality management system is an important tool for them to achieve sustainable development goals [13-18].

The economic mechanisms of many commercial companies, together with government regulation of the agro-industrial complex, are designed to ensure the implementation of the achievements of scientific and technological progress in all sectors of agriculture to support work on various tests of agricultural products, animal husbandry, seed production, and the training of qualified specialists. Environmental aspects add significantly to the quality of urban environment and therefore ensures green roofs in farming systems in this regard as the high-tech solutions in ecodevelopment [19-23]. At the same time, methodological, informational and consulting assistance is provided to agricultural enterprises. Environmental aspects of the choice of building materials in architectural design are the main elements of comparison in the rating systems of «Green» standards [24-31].

The purpose of our research is to analyze the market of existing green roofs and organic farms, as well as modern green technologies. The main objectives of the study include identifying trends in the field of green building and in the agricultural business, assessing the green roof market, and also considered the possibility of using modular technologies as vertical farms.

2 Functions and prospects for the use of green roofing

In this article the method of comparative analysis and analytical reviews to assess the green roof and green wall market were used. Theoretical and experimental analysis of the energy balance of green roofs and technological aspects of sustainable building design were analyzed [32-43]. The impact of facade and roof material on the thermal performance of building in the countries with a warm climate reviewed in several articles including Vietnam, Italy and other European countries [44-57]. Energy-saving aspects in architectural illumination was reviewed in research of A.K. Solovyov [58-60]. Energy-saving technology for the construction in civil engineering and the optimal organizational and technological solution for the construction of buildings and structures were analyzed [61-67]. Green technologies in construction are used not only in commercial buildings, but in low-rise housing and dwelling [68-71]. Methodological base of construction processes was used for solving the problems of organizational and technological modeling of construction processes [72-84]. Among the significant ecological directions, which implemented by Russian developers, the most popular are the economical work with water and the creation of additional recreational spaces on the roofs, including farming business. The Covid-19 pandemic and its socio-economic impact are pushing urban dwellers to grow fruits and vegetables in urban environments, and this could be an incentive for urban-agriculture development.

According to UN forecasts, by 2050 more than two-thirds of the world's population will live in cities. The Food and Agriculture Organization of the United Nations is calling for more attention to food security, arguing that rapid urbanization in developing countries is leading to nutritional deficiencies. Urban agriculture could be a necessary solution to feed people, potentially producing up to 180 million of ton of food per year, or about 10% of global legumes and vegetables, according to a 2018 study published in *Earth's Future*.

The largest urban farm in Asia is located on the rooftop of Tammsat University in Bangkok, Thailand [79]. It is open to anyone who wants to grow rice, vegetables and herbs. A portion of the 22,000 square meter roof is dedicated to solar panels that power the building. The purpose of using the truss on the roofs of buildings is to ensure urban food security (Fig. 1).



Fig. 1 - Urban farm on the rooftop of Tammsat University in Bangkok, Thailand [79]

The green roof has another function - it helps to mitigate the effects of climate change: floods caused by heavy rainfall or waves of unbearable heat, which are increasingly affecting residents of megacities. The green roof's cascading design allows rainwater to be collected, used to grow crops and stored in reservoirs up to 11 million liters of water for irrigation during dry periods. Green spaces protect the building from overheating and keep the building cool on hot days. The green farm is also an example of alternative organic farming. An example of a farm on the roof of a university building demonstrates that enough rice can be grown in a year to prepare a variety of rice and vegetable dishes for students and university staff with a supply of several months. Recycling technology assumes that all food leftovers will be sent to compost to be turned into fertilizer for the next harvest.

Thus, Singapore, which occupies the top position in the 2019 ranking of countries in the world for food security according to the Economist Intelligence Unit, is going to meet 30% of the country's food needs by 2030, increasing local supplies of fruits and vegetables. The first urban farm ComCrop was created in 2014 [80]. Peppers, lettuce, peppermint, basil and others are grown on the green roof of industrial buildings. On the roof, hydroponic technologies are used, which allow them to consume 90% less water than traditional agriculture. The produce from the farm is sent to supermarkets and restaurants. Rooftop farming company ComCrop is Singapore's urban farming pioneer (Fig. 2). Another bright realized project is Boston Medical Center's (USA, Massachusetts, Boston) rooftop farm on a 230-square-meter site that supplies fresh local produce to its patients and workers, which obtained Award of Excellence in Urban Agriculture in 2019.



Fig. 2 - Rooftop urban farming ComCrop in Singapore [80]

Taking advantage of the natural sunlight on the rooftop instead of using artificial light indoors means healthier vegetables, with lower production company can harvest faster-growing produce which is affordable and available in local supermarkets. Farms help to reduce the company's carbon footprint,

creates additional green spaces within the city, helps to reduce energy consumption, including by saving energy required [82,83,86].

3 Results and Discussion

Eco-development in the implementation of green urban farming is important attractiveness of real estate. According to estimates and data from the Grand View Research report, the market will be grow at a CAGR of 17% from 2021 to 2027 [14]. Grooflab is a green roof technology, designed by authors [81] with a long-term outlook on the green roof market, specializing in innovative, waste-free production of green roof modules from eco-plastic with integrated solar photovoltaic systems, wind turbines, micro-drip irrigation system and their combination (Fig. 3).

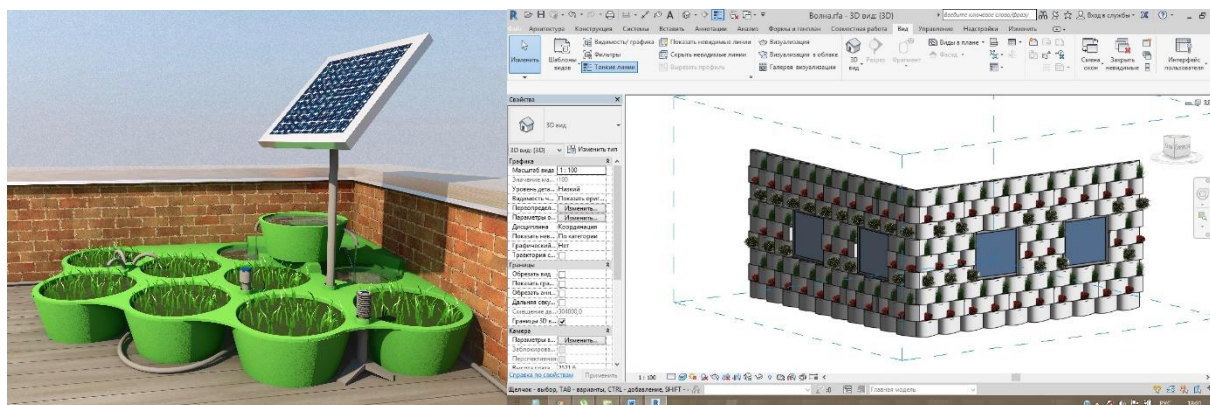


Fig. 3 - The modern urban farming in Russia, designed by authors

Despite the fact that Russia has a harsh cold climate, we still think more and more about green technologies both on the roofs of public buildings and on green walls. our development is to take into account not only the climatic features of Russia but also the technological advantages such as easy installation, ecological materials, lightweight construction and automatic irrigation systems. The integration of modular green systems in the buildings is actually an excellent example of increasing the economic efficiency of the green roofs. As a bright example of the successful implementation of the green roof technologies in Russian market is shown by Zinco [87], which was founded in Germany in 1957 and in 2009 a branch appeared in Russia. Urban agriculture is gaining more attention in the Russian market. Residents of the densely-populated Moscow and Moscow regions visit with their children green rooftops of modern restaurants, which are popular both in Russia and abroad. The organic farms have a public function, can barely handle the number of visitors in the spring and summer. In most cities worldwide there is more demand for land for vegetable gardens than is available. In Berlin 80,000 households have a vegetable garden and there are 16,000 on the waiting list. Modular systems as vertical farms is a perspective solution on green roof market for their easy use, fast installation as well as creative design [88-90].

4 Conclusions

Nowadays, in the pandemic conditions, the role of green roofs in the agricultural sector is very significant. In these conditions, the ecological sustainable technologies in green urban farming looks quite justified. The use of green technologies certainly increases the cost and, accordingly, the final price of housing by an average of 10-15%, but this overpayment quickly pays off. Directly this economic benefit is result by saving heat, water, electricity, indirectly - by providing a healthier environment. Attractive integrated green farming companies can be profitable with the direct sale of quality products, offering extra services, and the costs for the municipal green management can be reduced. To promote urban farming technologies in the real estate market, it is required not only to modernize construction processes, but also to conduct competent green marketing. The development and optimization of urban farming technologies is a very expensive process associated with significant capital costs, which means that real estate produced using green technologies will cost more than their non-ecological counterparts. The task of modern green roofs in increasing the economic efficiency of the agricultural sector of the



Russian economy is to focus the consumer on eco-conception of agricultural businesses and producing environmentally friendly technologies, calling for his social responsibility.

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