

## ECOLOGICAL AND ECONOMIC PROBLEMS OF ROOF GREENING

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**Abstract.** One of the rational ways to solve the problem of environmental pollution and energy savings is landscaping roofs. Their creation is becoming an increasingly popular element of ecological construction. The purpose of this article is to study the state of landscaping of roofs of buildings in the city of Lviv to identify environmental and economic problems and develop incentives to combat them. To achieve the goal of the study, a comprehensive approach was used, which includes the generalization and analysis of information, current regulations and experience in installing "green" roofs. While disclosing the content of the "green roof", a logical method was used. Methods of system analysis were used to identify structural links between landscaping roofs and solving environmental and economic problems; comparative analysis allowed to compare phenomena in order to establish similarities or differences between them. The article highlights the essence of the concept of "green" roof. Features of extensive type of roof landscaping and its ecological and economic problems are given. The calculation of the reduction of surface wastewater volume during the installation of green roofs at PJSC "Lvivsilmarsh Plant" was made and recommendations for their proper functioning were formed. Incentive measures to overcome environmental and economic problems of living roofs have been developed. Urban farming is proposed as a new element of ecological and economic policy of Lviv. **Conclusions.** The use of landscaping of roofs in both industrial zones and residential areas makes it possible to create a comfortable environment close to natural conditions, increases the recreational and aesthetic attractiveness of the urban environment and improves its economic performance.

**Keywords:** environment, ecospace, landscape design, roof constructions, energy saving, water saving, real estate, urban farming, ecological safety, economic responsibility.

**JEL Classification:** P18, Q41, Q57

**Formulas:** 3; **fig.:** 3; **tabl.:** 2; **bibl.:** 31

**Introduction.** In connection with the industrialization of society, namely, the growth of cities and population, the increase of residential and public buildings that are put into operation, the development of all modes of transport, etc., especially exacerbated the problem of energy conservation and pollution. The increase in residential buildings in the city of Lviv affects the comfort of living. One of the rational ways to solve the problem of environmental pollution and energy savings is landscaping. Only modern technologies for creating and restoring a green environment that can change the ecological situation.

Landscaping is a measure aimed at improving the ecological condition of the environment of the city of Lviv and landscaping of its territory. Green roofs as an element of landscape architecture and design have recently become more and more of interest to society. As a rule, objects of social infrastructure are subject to such process: public centers, city streets and squares, parks, squares. But given the balance of the current environmental situation and landscaping of cities, as practice shows, such measures are either not always enough for a healthy and prosperous existence of the population, or they apply only to a certain part of the city (due to lack of "ecospace"). In this regard, there is interest and need for alternative methods of landscaping, the objects of which are the roofs of buildings. Currently, this type of

landscaping is becoming an increasingly popular element of ecological construction. Roof landscaping has gained recognition and spread around the world, even in countries with cold climates, where during the winter the plants may lose their aesthetic appeal. Therefore, in such an urbanized city as Lviv, the use of green roofs is especially important.

**Literature review.** Advantages and disadvantages, technical features of green roofs are revealed in the works L.M. Dadiverina, A.V. Reed (Dadiverina & Komishnya, 2018), M.A. Minyailo, O.I. Filonenko (Minyajlo & Filonenko, 2015), V.I. Solonenko, O.B. Watamanyuka (Solonenko & Vatamanyuk, 2017) and others. In studies of V.M. Shuvalov and M.M. Saadoma (Shuvalov & Saad, 2016) the relevance of the use of "green" roofs is based on the fact, that large cities face problems of air pollution and noise. Scientists A. Fedorov, F.G. Stolyarova, P.S. Kordyukov, M.C. Osintseva (Fedorova, Stolyarova, Kordyukov & Osintseva, 2013) consider the durability of "green" roofs, namely the range of plants that are most suitable for planting on the roof. Scientists V.M. Filipenko, R.G. Abakumov (Filipenko & Abakumov, 2017) determine the factors that increase the investment attractiveness of green buildings. In the works of T.V. Prilipko, T.E. Potapova, O.V. Siromakha (Prilipko, Potapova & Syromakha, 2015) and V.A. Gorokhov (Gorokhov, 2012) is shown the relationship between the decrease in the number and quality of greenery and the deterioration of the health of the city population (there is an increase in the number of diseases of the respiratory system, nervous system, etc.).

However, despite the significant amount of research on this issue, many issues of natural and economic nature in the field of management of green areas remain poorly understood. These studies did not focus on development stimulating measures to overcome environmental and economic problems of landscaping roofs.

**Aims.** The purpose of this article is to study the state of landscaping of roofs in Lviv to identify environmental and economic problems and develop incentives to overcome them. Achieving this goal determines the solution in the process of the study of the following tasks: to determine the features of the extensive version and the layered structure of the system of "green" roofs; identify the main environmental and economic problems of designing and creating landscaping roofs; calculate the reduction of surface wastewater during the installation of a green roof at PJSC "Lvivsilmash Plant"; to form recommendations for the proper functioning of green roofs; develop incentive measures to overcome environmental and economic problems of roof landscaping; to offer a new element of ecological and economic policy of the Lviv city.

**Methods.** To achieve the goal of the study, a comprehensive approach was used, which includes the generalization and analysis of information, current regulations and experience in installing "green" roofs. When disclosing the content of the "green roof", a logical method was used; methods of system analysis - to identify structural links between landscaping roofs and solving environmental and economic problems; comparative analysis - allowed to compare phenomena in order to establish similarities or differences between them.

**Results.** The practical implementation of ecological and economic development of a large city should include the following factors: cooperation of public authorities, local governments, NGOs, science, business in solving problems and developing recommendations for integrated environmental protection, implementation of "clean", resource- and energy-efficient technologies, environmentally balanced systems of nature management and preservation of the city's eco-system, guaranteeing ecological safety for the health and life of the population, ensuring social welfare and economic stability. The object of management in this case is the city ecological and economic system. Leaders of ideas and practical actions for the dissemination of "green" approaches in the development of ecological and economic system in different countries are Green Building Councils (Green Building Councils), which are created according to the model and under the auspices of the World Council. In the United States, the USGBC Council unites more than 15,000 legal entities, the developer of the LEED standard, in Ukraine - the Ukrainian Council for Green Building (UaGBC), which is a public organization.

Environmental problems associated with landscaping of densely populated cities can be solved without using radical options for changing areas. Currently, special attention is paid to the development of modern methods of forming zones of ecological comfort. Within the framework of this direction, the following measures are carried out creation of living roofs of buildings; use of vertical plant facades; construction of eco-parks. Recently, the leader in the direction of "green" construction is the landscaping of roofs, which has long been used to increase the comfort and attractiveness of the appearance of houses.

From the point of view of L.M. Dadiverina and A.V. Komyshnaya, green roof is a combination of construction technologies and techniques of landscape design, i.e. it is the roof of the building, partially or completely covered with soil and vegetation (Dadiverina & Komishnaya, 2018). Scientists O.V. Nilova and Z.S. Moskalenko argue that roof landscaping is a free area of space that can be used for rest and recovery (Nilova & Moskalenko, 2019).

In our opinion, a green roof (ecological roof, operated roof, living roof and vegetation roof) is a roof that partially or completely is covered with vegetation, located in the upper part of the roof structure on a waterproof membrane with a nutrient layer. It should be noted that in modern practice, the creation of "green roofs" is the most widespread extensive option.

At extensive gardening applies the plants, which maintain adverse conditions. They are usually low and fast growing, drought- and winter-hardy, do not require frequent watering and fertilizing, should not emit allergens. This is how perennial herbaceous plants, succulents, cereals and lawn grasses are used. The studied species, which belongs to the first group, is *Pseudofumaria lutea* L., of the *Papaveraceae* Juss-Borkh family. (The Plant List, 2020). The natural range covers the forest areas of the Southern Alps, despite the fact that it is a sciogeliophyte; it has proven itself well on green roofs. The undeniable advantages of this species include its life form - a geophyte-cryptophytic (Raunkiaer, 1934), which allows it to survive adverse periods - frosts in winter and drought in summer. This species is highly decorative,

constantly blooms, is virtually undamaged by diseases and pests, is non-invasive, and in favorable conditions leaves the basal leaves evergreen, increasing the decorative plant compositions (Missouri Botanical Garden, 2020). By USDA-zoning, *Pseudofumaria lutea* is suitable for planting in 4-8 zones of frost resistance, while the territory of the city of Lviv belongs to zone 6 and it is well suited for the roofs of the city (Heinze & Schreiber, 1984).

For landscaping roofs that are in the shade, you can use the species *Sedum* L., which belongs to the second group of plants. In an urban environment, one of the most suitable for use on flat roofs is the system "Sedum carpet", which is created on many roofs of buildings in Lviv. It includes such species and their cultivars as *Sedum aizoon* L., *Sedum acre* L., *Sedum album* L., *Sedum hybridum* L., *Sedum kamtschaticum*, *Sedum rupestre* L., *Sedum spurium*, *Sedum spectabile*, *Sedum alpestre*, *Sedum ewersii*.

The system of landscaping the roof using lawns is created from a mixture of plants - cereals: *Festuca rubra* L., *Lolium perenne* L., *Poa pratensis* L. Occasionally they are supplemented by solitary plantings of other cereals - *Calamagrostis epigejos* (L.), *Miscanthus sinensis*, *Festuca glauca*, *F. amethystina* L., creating a garden of cereals. This is the third group.

It will be great to see representatives of the genus *Sempervivum* L. (W.D.J. Koch) lay on the green roof. The leaves of these plants are covered with a special waxy coating, which prevents the evaporation of moisture. Therefore, they do not require additional watering. Bright green color can complement any architectural structure (Minyajlo & Filonenko, 2015).

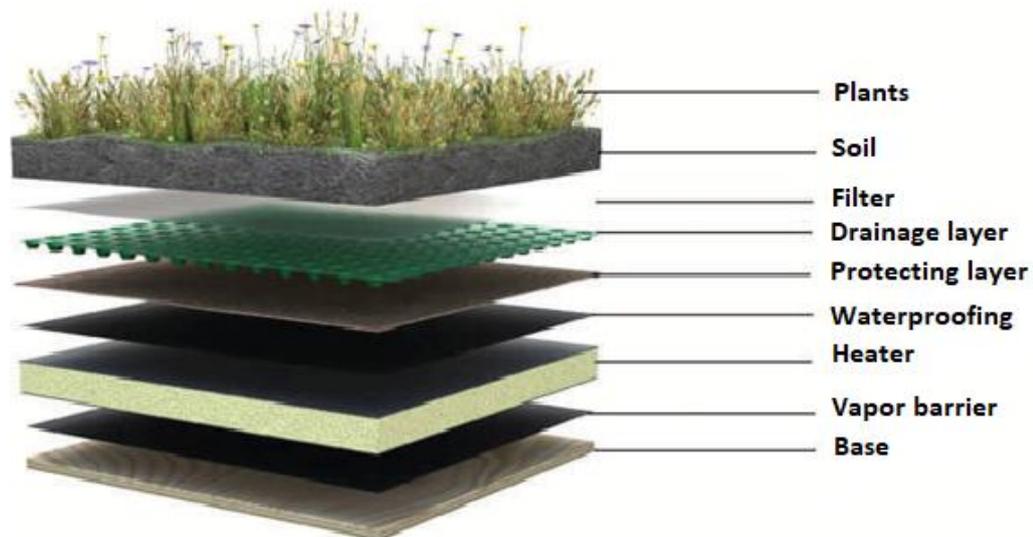
Access of people to such roof for recreation is not provided and movement is possible only on special paths. This type of landscaping can be widely used in the arrangement of industrial enterprises, garages and shops (Skabelkina, 2017; Tsurkina, Laketic, Laketic & Korenkova, 2016; Solonenko & Vatamanyuk, 2017). Outside the city, the roofs of houses, gazebos, terraces, sheds and other outbuildings are planted in this way. Roofs with a slope of at least 4 degrees must be equipped with a drainage system, otherwise there will be stagnation of water in the soil and, consequently, increase the load on the roof.

An example of an extensive type of roof landscaping can be seen in Fig.1.



**Figure 1. Extensive type of roof landscaping (photo by O.E. Galevich)**

As can be seen from Fig. 1, plants need soil and moisture for growth, respectively, the technology of extensive "green" roof involves the creation of a special structure in which each layer performs its specific functions (Fig. 2).



**Figure 2. Layered structure of the "green" roof system**

According to scientists V.P. Ocheretny, T.E. Potapova, D.M. Kuzmina and V.M. Sologor, the main problem why there are no green industrial roofs in Lviv is the misunderstanding that by installing a green roof with the right technology, you can completely forget about waterproofing repairs. Such roofs can hold up to 80% of rainwater, which is a reduction in the load on urban sewage, which often does not cope with rainwater volumes, fails, leading to flooding (Prilipko, Potapova & Syromakha, 2015; Ocheretny, Potapova, Kuzmina & Sologor, 2017).

Therefore, for landscaping large roofs (industrial and warehouses) it is advisable to use the extensive type, because it is cheaper, and the roof does not require special care and additional strengthening of structures enclosing buildings.

From our point of view, in order to stimulate the owners of industrial zones in water retention in the areas of their roofs, we will fulfill the forecast of reducing the volume of surface wastewater during the installation of green roofs. The calculations will be applied to two industrial sites of one of the agricultural machine-building enterprises in Lviv (PJSC Lvivsilmarsh Plant).

Annual volume of surface wastewater,  $W$ ,  $m^3$ :

$$W = W_d + W_t, \quad (1)$$

where  $W_d$  is the volume of surface wastewater discharged during the warm period (volume of rainwater),  $m^3$ ;  $W_t$  - volume of surface wastewater discharged during the cold period (volume of melt water),  $m^3$ .

The volumes of surface runoff discharged during the warm and cold periods of the year are determined according to the formulas (SOU ZhKG, 2009: 18):

$$W_d = 10 \cdot h_d \cdot k_d \cdot F, \quad (2)$$

$$W_t = 10 \cdot h_t \cdot k_t \cdot F, \quad (3)$$

where 10 is the coefficient of alignment of the dimensions  $h_d$  and  $F$  to obtain the values of  $W_d$ ,  $W_t$  in  $m^3$ ;  $h_d$  - average annual precipitation layer for the warm period of the year, mm, for Lviv is 475 mm (DSTU - NBV. 1.1 - 27: 2010, 2011);  $h_t$  - annual layer of precipitation for the cold period of the year, mm, is 225 mm (DSTU - NBV. 1.1 - 27: 2010, 2011);  $k_d$  - rainwater runoff coefficient, taken equal to the weighted average value for the entire catchment area, taking into account the average

values of runoff coefficients of surfaces of different types;  $k_t$  - melt water runoff coefficient;  $F$  - catchment area, hectare.

According to the current normative document in Ukraine (Order of the Ministry of Housing and Communal Services, 2010), the value of the total runoff coefficient for rainwater must be taken as: for waterproof coatings in the range of 0.6–0.8, for soil surfaces - 0.2, for lawns - 0.1, and for melt runoff, regardless of the type of coating - in the range of 0.5-0.7. According to research L.I. Vovk and Yu.A. Trofimchuk, it is recommended the use of the normative document "Rules for the use of centralized municipal water supply and sewerage systems in settlements of Ukraine", according to which the runoff coefficient for rainwater must be taken as 0.7 (for waterproof coatings), and for melt water regardless of the type of coverage - 0.6 (Vovk, Trofimchuk, 2018).

It is also worth noting that the environmental technologies of the German company Wilo have the best reputation in the world in the field of rainwater. This company has developed a reference guide for the use of rainwater. This guide provides examples of calculating rainwater inflows, determining water needs, calculating the volume of a rainwater storage tank and selecting a water supply system. In addition, it is interesting and valuable for our study to introduce the coefficient of runoff ( $c$ ) for different types of roof surfaces, including extensive green roofs (Wilo, 2016; Ferrans, Rey, Pérez, Rodríguez, Díaz-Granados, 2018). In the Ukrainian DNB 2.6-14-97 and DNB B.2.6-220: 2017 such a technique is absent.

Sites of agricultural machinery, in addition to the general patterns in the formation of quantitative characteristics of surface wastewater, have differences, which are mainly due to the different proportion of permeable surfaces in the total catchment area (for sites of main production, compared with sites of ancillary production administrative buildings).

The results of calculations of the volume of surface wastewater discharged in the city sewerage network from the site of the main and auxiliary productions of PJSC "Lvivsilmash Plant" and their projected values in the arrangement of green roofs are given in table. 1.

Thus, the arrangement of green roofs on the production buildings of industrial enterprises in Lviv will provide:

1. Reduction of surface wastewater discharged in the city storm sewer network by almost 2.5 times (by 60%), reducing the load on them during heavy rainfall.
2. Reducing the level of harmful substances in the air due to the absorption of carbon dioxide and the release of oxygen in the industrial zone.
3. Increasing the durability of the roof structure by 2.5-3.5 times, as the green roof performs a protective function against exposure to UV rays and overheating.
4. Reducing energy costs for heating and cooling, as a green roof serves as a natural insulator.
5. In the event of a fire, such a roof will prevent its spread.

**Table 1. Determination of the volume of surface wastewater from the territory of PJSC "Lvivsilmash Plant"**

Name	The site of the main production	Additional production site
Total area, hectares	49.9	72.29
Area of waterproof surfaces, ha	16	28.9
With a roof		
Rainwater runoff ratio	0.7	0.7
Melt water runoff coefficient	0.6	0.6
Volume of surface wastewater during the warm period, m <sup>3</sup>	53.2	96.09
Volume of surface wastewater during the cold period, m <sup>3</sup>	21.6	39.02
Annual volume of surface wastewater, m <sup>3</sup>	74.8	135.11
When installing a green roof		
Rainwater runoff ratio	0.3	0.3
Melt water runoff coefficient	0.6	0.6
Volume of surface wastewater during the warm period, m <sup>3</sup>	22.8	41.2
Volume of surface wastewater during the cold period, m <sup>3</sup>	21.6	39.02
Annual volume of surface wastewater, m <sup>3</sup>	44.4	80.22
Decrease in annual quantity of surface sewage of waters discharged in the city storm sewer network, m <sup>3</sup> /%	30.4 / 60.0	54.89 / 60.0

Therefore, among other advantages of application of extensive "green" roofs the scientist A.V. Bezkorovaina distinguishes the following: increasing sound insulation, using them as a recreational area and obtaining economic benefits from it (Beskorovainaya, 2015). A.I. Yevtushenko, V.E. Nuriev, V.V. Zotov and V.I. Vinogradov (Evtushenko, Nuriev, Zotov & Vinogradov, 2018) note similar advantages: green roofs do not overheat in summer and provide additional insulation in winter, provide sound insulation and have a longer service life. That is, in addition to an attractive appearance, green roofs solve problems of both environmental and economic nature. Numerous scientific investigations and practical experience confirm the positive impact of green roofs on climate, vegetation diversity and the overall landscape of the city (Berto, Stival, Rosato, 2018; Shafique, Kim & Rafiq, 2018; Teotónio, Silva, Cruz, 2018).

In general, the study of the impact of industrial enterprises roofs extensive landscaping on the state of the ecological and economic system of Lviv revealed the positive impact of greenery on the main parameters that characterize the quality of the environment and is expressed in the following:

1. Extension of a life cycle of a roof without repair, thanks to protection against the aggressive environment and mechanical influences. Saving money, the roof covered with tar is replaced on average in 20 years, but its service life increases by 2-3 times;

2. Water conservation, rainwater absorption occurs. Such water can be reused in production.

3. Reduction of rainwater. Can hold water by 60%. Reducing the load on the city sewage by rainwater runoff - reducing the money spent on sewage.

4. Acoustic comfort. Reduce sound reflection on the roof surface and improve sound insulation to 8 dBs. The soil layer absorbs low frequencies, and plants - high. Protection against electromagnetic radiation.

5. Reduction of carbon dioxide emissions generated by electricity generation at power plants for air conditioning and heating. Absorption of 0.5 kg of harmful particles per square meter. Dust neutralization (University of Duisburg (Germany): 1,000 m<sup>2</sup> of extensive roof landscaping absorbs 8 kg of dust per year; Singapore: the air near the green roof contains 37% less sulfur dioxin and 21% less carbon monoxide; Michigan, Detroit (USA): 20% of the roofs of these cities, which are green, neutralize 889 tons of nitric oxide per year, University of Michigan (USA): environmental impact of landscaping 20% of the surface of all roofs of the city (17,000 planted street trees) (Dadiverina & Komishnya, 2018).

6. Production of additional oxygen. German scientists R. Schubert and M. Meisterhaus proved that a grassy lawn on a roof of only 150 m<sup>2</sup> produces oxygen that can breathe 100 people, and a green roof of 48 m<sup>2</sup> produces as much oxygen as a tree with a crown about 10 m in diameter (Seroshtan, 2015). As a result, landscaping the roofs of the city helps to reduce air pollution and enrich it with oxygen, which increases the comfort of life and reduces the number of diseases, especially asthmatic.

7. Reducing the cost of cooling the building by 15-19% due to the natural evaporation of moisture. Studies show that in summer a high concentration of green roofs can significantly reduce the average temperature of the whole city by 2-5 °C.

8. The green roof becomes a new living space for flora and fauna. Dozens of species of plants, including rare ones, dozens of species of insects, birds and other small animals can survive on green roofs (Solonenko & Vatamanyuk, 2017).

9. Reducing the cost of repair and maintenance of the roof.

10. Additional income from the lease of land on the roof.

11. Increasing the value of real estate.

12. Good aesthetic appearance of buildings.

13. Reducing the cost of heating of the upper floors of the building in winter and cooling of rooms in summer.

The value of alternative forms of roof landscaping is not only in the renewal of the ecosystem, but also in energy efficiency. This area became especially relevant in Europe in the 60's during the energy crisis. Currently, energy efficient technologies are very relevant for Lviv. Extensive green roofs in residential areas are a kind of temperature buffer that improves energy consumption for heating in winter and cooling in summer. Green roofs contribute to the thermal insulation of the house. The savings directly depend on the climate, composition and amount of substrate, the height of the roof structure and the selection of the range of plants, so the economic effect will be individual for each roof.

For example, in winter, the effect of thermal insulation with extensive landscaping and a substrate height of only 10 cm can be improved by 10%. The difference in temperature on the surface of the waterproofing without landscaping can reach 100° C during the year. Especially in summer, a green roof helps to reduce the heat load to about 60%.

Numerous studies in this area converge in one; green roofs help to smooth out effectively temperature jumps. The greatest thermal insulation is achieved in summer, by cooling the upper floors of the building. For example, the temperature of the roof structure under the green roof system, at an ambient temperature of 30 °C, is 17.5 degrees. The thickness of the substrate is only 16 cm in January at -14 °C; the temperature under the plant environment is 0 degrees. The economic effect is to reduce the cost of heating and air conditioning of buildings by an average of 20-30%.

It is important that in Ukraine landscape and recreational planning of settlements is regulated by DBN 360-92 "Planning and development of urban and rural settlements" (Order of the State Commission for Urban Development, 1992), as well as the State sanitary rules of planning and development of settlements (Order of the Ministry of Health, 1996).

Standards for "green" construction in Ukraine are voluntary (Zinchenko, 2015). In many ways, the activities of the Ukrainian Council contribute to the implementation of these standards. The priority areas of its work are:

- implementation of international standards of "green" construction in the country;
- certification of real estate for compliance with the standards of "green" construction;
- organization of conferences, seminars and "round tables" on "green" construction for construction and energy professionals, environmentalists and lawyers;
- popularization of ideas of "green" construction.

The existing document DBN-360 (Order of the State Commission for Urban Development, 1992) states that in the conditions of compacted construction, the use of vertical landscaping is allowed, as well as the arrangement of gardens on the roofs of buildings. However, there are no rules for the design and creation of landscaping roofs. Thus, all landscape design companies engaged in landscaping roofs in Lviv today have no idea about the correctness of their design, which leads to a gross violation of technology, safety and reduced service life of facilities. Exceptions may be international companies (e.g., ZinCO, FlorDepot), operating in the Ukrainian market according to European standards and technologies.

Also, the main problems of extensive landscaping of roofs - the destructive force of the crustal system and wind loads, so the design is quite complex. It usually has several insulating layers, additional windbreaks and a special irrigation system. The soil layer for plants should be 30-40 cm, to create a lawn - 15 cm. Permissible loads in the case of extensive landscaping when saturating the soil with water should not exceed 70 kg/m<sup>2</sup> of surface. New technologies of arrangement of "green roofs" include the whole complex of construction works. This is a solution to waterproofing,

the device of the drainage layer with the necessary filtration. Depending on the specific conditions of the composition and the number of layers of green roofing can vary within the widest range, each time meeting a specific task.

Among other ecological and economic problems of landscaping of roofs, it is possible to allocate the following: before installation it is necessary to carry out examination of the building and a roof; engineering and technical complexity of design; the emergence of a high level of humidity, so before planting covered with special materials that provide waterproofing of the roof; high cost of installing a green roof (from 100 to 200 euros per 1 m<sup>2</sup>); plants are found in unnatural conditions (temperature difference, negative effects of wind, increased evaporation of moisture, negatively affects their growth and development); in the event of a roof leak, repairs will cost much more, and the cause of the problem is much more difficult to establish; application of a heating drainage system so that at a negative air temperature the soil layer does not freeze.

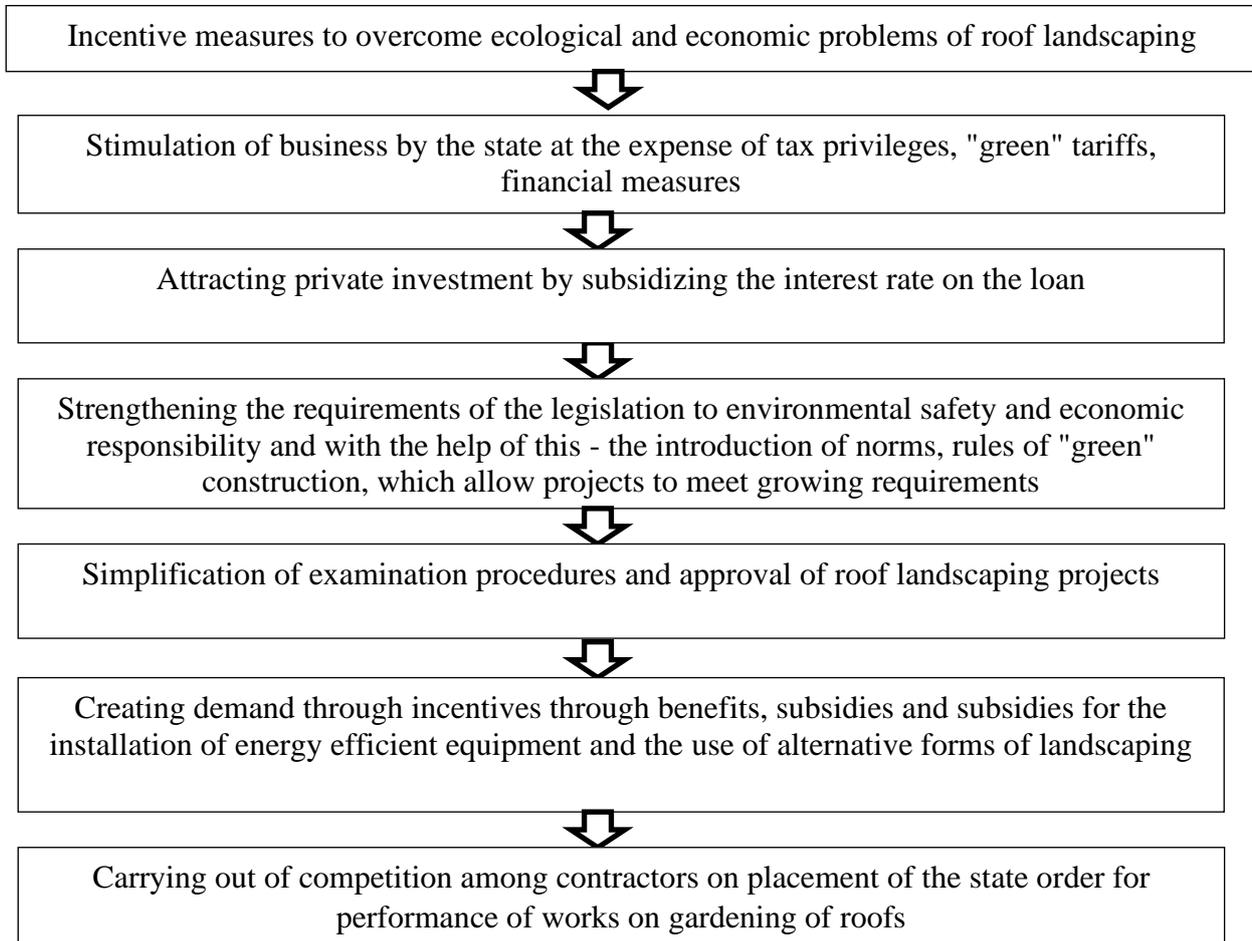
Another reason for abandoning green roofs in Lviv is, unfortunately, the low quality of construction and installation work. Installation of such a roofing system requires special knowledge and experience. Additional difficulties and financial costs are borne by the service system, because the plants need constant care. Opinions "against" are due to time and lack of knowledge and information, little experience in this field of domestic architects, design engineers, contractors, operating organizations, and sometimes the customers themselves.

As it was mentioned above, in order to increase the effectiveness of care for the roof and the plants that are planted on it, we have proposed the following recommendations: monitoring the flow 2 times a year (autumn and spring after heavy rains and snowmelt); monitoring of the flow 2 times a year (autumn and spring period after heavy rains and snowmelt); conducting regular monitoring of the condition of green plants (at the slightest signs of freezing, various diseases, it is necessary to provide quality treatment and care); in the presence of system of auto-irrigation and lighting of carrying out maintenance before the beginning of operation and at the end of operation; in case of weeding, its immediate removal is required; in the dry season in the absence of an auto-irrigation system additional watering of a green roof is necessary; in especially snowy period it is necessary to remove excess snow to reduce the load on the building; when the substrate layer subsides, its backfilling is required; with a large slope of the roof it is necessary to use a geogrid to avoid washing away the substrate and the layer of green plants during heavy rains and snowmelt.

In addition, one of the significant factors in increasing the environmental and economic value of the urban area is the regulatory system that ensures the preservation and development of landscaping and contribute to the normalization of the environmental situation, as well as improving living standards.

The strategy of improving the existing system of landscaping roofs should be implemented based on budget self-sufficiency of the "green" municipal sector through the development of a transparent scheme of financial flows, targeted use of accumulated funds from the operation of green spaces, widespread use of tools that increase economic responsibility, operation of green areas, including compensation

payments, consideration of landscaping in the calculation of rent, financial guarantees of contractors for the volume and quality of work performed. Along with this, the necessary components of effective management of landscaping roofs are forecasting the need for greenery for different areas of the city of Lviv based on an inventory of green roofs and the use of incentives (Fig. 3).



**Figure 3. Incentive measures to overcome ecological and economic problems of roof landscaping in Lviv**

*Source: author's development*

**Discussion.** The domestic and foreign literature highlights a number of proposals for improving the environmental and economic policy of cities and the state as a whole. From our point of view, urban farming can be an important step in this direction. As a result of "panic purchases" during the COVID-19 pandemic, the demand for food exceeded the possibilities of prompt deliveries. Store shelves emptied.

This situation gives an important signal: in the future, it is necessary to create more self-sufficient cities and districts, which, if necessary, will be able to provide citizens with food and necessities. Using urban spaces to grow vegetables, fruits, legumes, poultry, small livestock and even fish can be a solution. Urban farms and greenhouses can be set up on the roofs of buildings - a huge unused area in cities - and provide homeowners with direct access to fresh food, which will help avoid panic in global crises.

Urban farming can be a powerful economic stimulus for the urban economy of Lviv - a new economic sector is emerging, which means new jobs for people who could take care of plants. Farms can be used both by locals for personal needs and by business - restaurants, cafes will be able to grow their own products on their roof.

**Conclusions.** Thus, the use of landscaping roofs in both industrial areas and residential areas makes it possible to create a comfortable environment close to natural conditions, increases the recreational and aesthetic appeal of the urban environment and improves its economic performance. In addition to the architectural-planning and aesthetic role, green roofs solve a number of problems: clean the air from emissions from transport and industrial enterprises; reduce noise, improve microclimatic conditions; increase humidity; reduce wind force, air temperature in summer and increase it in winter; perform a sanitary-protective role, thus supporting the livelihood of the city population; reduce the cost of repair and maintenance of the roof; contribute to the formation of additional income from the lease of land on the roof; increase the value of real estate. In addition, the quality of landscaping affects the well-being and health of city residents.

In the modern city in a densely built-up and cold climate, the problem of compensation of greenery using green roofs helps to increase the comfort of living in the home, as well as improving the environmental and aesthetic characteristics of both individual apartments and the house as a whole. Also, should be optimized the architectural and landscape organization of the urban environment, functional, microclimatic and sanitary parameters of entire cities. The use of green roofs in modern Ukrainian construction and design requires certain adapted developments of methods and approaches based on the experience of foreign countries. Thus, the issue of landscaping roofs, which is a promising component of "green" construction, remains open today. This is due to the lack of regulatory documentation, difficult economic and political situation, mentality. In this regard, the need to develop management decisions that help mobilize the ecological potential of green spaces and economic resources, aimed at developing a complex of green areas of cities (as the issue of improving the mechanism to stimulate greening of roofs), is an important condition for improving the implementation of environmental and economic politics of cities and the state in general.

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