Economic and Ecological Optimization of the Method of Growing Trees on the Roof

Nguyen Thi Hang

Abstract — **Landscape on the roof is one of the reasonable ways to solve the problem of environmental pollution and save energy. An increasingly popular element in ecological construction is our Creativity. The aim of this paper is to study the current state of the landscape of the roofs of buildings in the city of ThaiNguyen in order to identify environmental and economic problems and develop incentives to combat them. Before discovering the contents of the "green roof", a logical approach was used. Systems analysis methods have been used to identify structural links between landscape roofs and address environmental and economic issues; Comparative analysis allows the comparison of phenomena to establish similarities or differences between them. The article clearly states the essence of the concept of a "green" roof. The features of the spacious rooftop landscape type and its economic and ecological issues are presented. The calculation of the reduction of surface wastewater during the installation of green roofs at "ThaiNguyen Plant" has been carried out and recommendations for their proper operation have been formulated. Incentives to overcome the environmental and economic problems of living roofs have been developed. Urban agriculture is proposed as a new element in the economic and ecological policy of ThaiNguyen. Conclude. The use of landscaped roofs in both industrial and residential areas can create a comfortable environment close to natural conditions, increase the recreational and aesthetic appeal of the urban environment, and improve economic efficiency of the city.**

***Index Terms*— ecospace, landscape design, roof constructions, energy saving, water saving, real estate, farming.**

I. INTRODUCTION

In addition to the industrialization of society, namely the growth of cities and populations, the proliferation of residential areas and public works put into operation, the development of all modes of transport, etc., especially aggravate the problem of energy saving and pollution. The increase in residential buildings in the city of ThaiNguyen affects the comfort of life. One of the reasonable ways to solve the problem of environmental pollution and save energy is landscape. Only modern technologies for creating and restoring green environments can change the ecological situation. Beautiful landscaping is a measure aimed at improving the ecological condition of the environment of the city of ThaiNguyen and the landscape of its territory. Recently, architecture and landscape design are increasingly interested in society, it creates green roofs. Usually, the objects of social infrastructure are the objects of that process: public centers, streets and squares, parks, squares. Given the balance of the current environmental situation and the landscape of cities, especially industrial cities, as practice shows, such measures are not always sufficient for a healthy existence. and the well-being of the people, or they only apply to a certain part of the city (due to the lack of "ecospace"). In this regard, there is interest and need for alternative landscaping methods, the object of which is the roofs of buildings. Currently, this type of landscape is becoming an increasingly popular element in ecological construction. Rooftop landscaping has gained recognition and spread all over the world, even in countries with cold climates, where in winter, trees can become unsightly. Therefore, in an urbanized city like ThaiNguyen, the use of green roofs is especially important.

Nguyen Thi Hang, Faculty of Civil and Environment, Thai nguyen University of Technology, Thai Nguyen, Vietnam.

II. 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 ThaiNguyen 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 "ThaiNguyen 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 ThaiNguyen city.

III. 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.

IV. 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 & Komishnya, 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 ThaiNguyen 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 ThaiNguyen. 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, Laketich, 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.

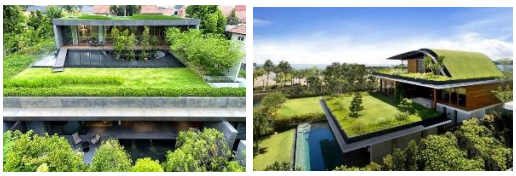

Figure 1. Extensive type of roof landscaping

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).

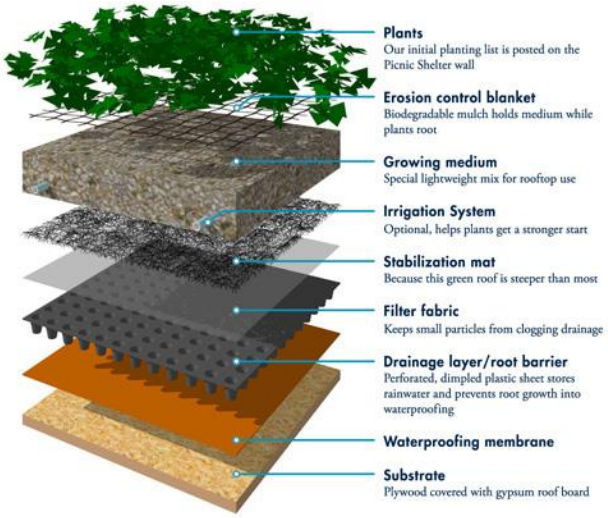

Figure 2. Layered structure of the "green" roof system

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 ThaiNguyen 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 ThaiNguyen (ThaiNguyen 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 ThaiNguyen 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 I for different types of roof surfaces, including extensive green roofs (Wilo, 2016; Ferrans, Rey, Pérez, Rodríguez, Díaz-Granados, 2018). In the Ukrainian DBN 2.6-14-97 and DBN 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 “ThaiNguyen 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 ThaiNguyen 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 "ThaiNguyen 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^3	53.2	96.09
Volume of surface wastewater during the cold period, m^3	21.6	39.02
Annual volume of surface wastewater, m^3	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^3	22.8	41.2
Volume of surface wastewater during the cold period, m^3	21.6	39.02
Annual volume of surface wastewater, m^3	44.4	80.22
Decrease in annual quantity of surface sewage of waters discharged in the city storm sewer network, m^3/%	30.4 / 60.0	54.89 / 60.0

Therefore, among other advantages of application of extensi"e "gr"en" 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 ThaiNguyen 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 runo–f - 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 plan–s - 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 m2 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 m2 produces oxygen that can breathe 100 people, and a green roof of 48 m2 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 ThaiNguyen. 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 100º 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-“2 "Planning and development of urban and rural settleme”ts" (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 f‘r "gr”en" 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 “f "gr”en" construction in the country;
- certification of real estate for compliance with the standards “f "gr”en" construction;
- organization of conferences, seminars a“d "round tab”es" “n "gr”en" construction for construction and energy professionals, environmentalists and lawyers;
- popularization of ideas “f "gr”en" 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 ThaiNguyen 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 roo–s - 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 la–n - 15 cm. Permissible loads in the case of extensive landscaping when saturating the soil with water should not exceed 70 kg/m2 of surface. New technologies of arrangement “f "green ro”fs" 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 m2); 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 ThaiNguyen 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. Opinio“s "agai”st" 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 t“e "gr”en" 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 ThaiNguyen based on an inventory of green roofs and the use of incentives (Fig. 3).

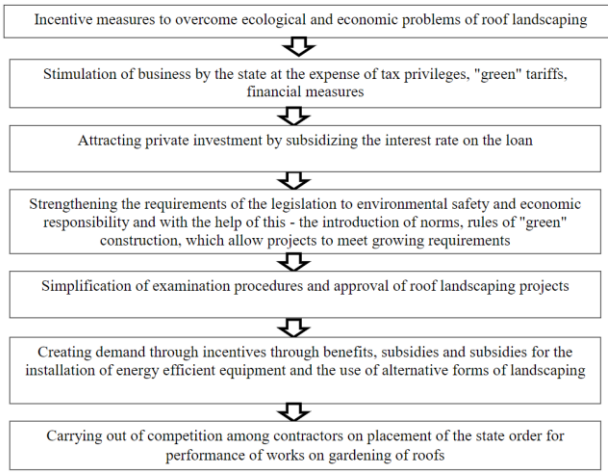

Figure 3. Incentive measures to overcome ecological and economic problems of roof landscaping in ThaiNguyen

V. 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 ThaiNguyen - 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.

VI. CONCLUSION

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 architecturalplanning 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.

VII. Acknowledgments

In this article, we would like to especially thank to Thainguyen University of Technology, Vietnam for supporting us in the experimental process.

VIII. REFERECES

[1]. Beskorovainaya, A.V. (2015). Effektivnost primeneniya ekspluatiruemyih krovel [Efficiency of using the operated roofs]. *Nauchnyiy vestnik Voronezhskogo gos. arh.-stroit. un-ta - Scientific Bulletin of the Voronezh State architect-builds un.*, 1, 86-89 [in Russian].

[2]. Dadiverina, L.M., & Komishnya, A.V. (2018). Inzhenerni, ekonomichni, sotsialni ta ekolohichni perevahy zelenoi pokrivli [Engineering, economics, social and ecologic transitions of green cover]. *Visnyk Prydniprovskoi derzhavnoi akademii budivnytstva ta arkhitektury - Bulletin of the Transnistrian State Academy of Education and Architecture*, 5 (245-246), 60-65 [in Ukrainian].

[3]. DSTU - NBV. 1.1 - 27: 2010. (2011). Construction climatology. Kyiv: Ukrarkhbudinform [in Ukrainian].

[4]. Evtushenko, A.I., Nuriev, V.E., Zotov, V.V., & Vinogradov, V.I. (2018). Innovatsionnyie metodyi dopolnitelnogo ozeleneniya gorodskogo prostranstva [Innovative methods of additional landscaping of urban space]. *Inzhenernyiy vestnik Dona - Don's Engineering Bulletin*, 3 (50), 122 [in Russian].

[5]. Fedorova, T.A., Stolyarova, F.G., Kordyukov, P.S, & Osintseva, M.S. (2013). Tehnologicheskie printsipyi podbora rasteniy i inzhenernyie osobennosti ozeleneniya krovel evropeyskoy chasti Rossii [Technological principles of plant selection and engineering features of roof gardening in European Russia]. *Vestnik RUDN - RUDN Bulletin*, 5, 105-112 [in Russian].

[6]. Filipenko, V.M., & Abakumov, R.G. (2017). Razvitie sovremennogo «zelYonogo» stroitelstva v Rossii [Development of modern "green" construction in Russia]. *Innovatsionnaya nauka - Innovative science*, 41, 207-210 [in Russian].

[7]. Gorokhov, V.A. (2012). *Zelenaya priroda goroda [Green nature of the city]*. Moscow: Architecture-S [in Russian].

[8]. Minyajlo, M.A., & Filonenko, O.I. (2015). Sady na dakhakh ta yikh sotsialno-ekonomichnyi vplyv [Roof gardens and their socio-economic impact]. *Stroytelstvo, materyalovedenye, mashynostroenye: sbornyk nauchnikh trudov - Construction, materials science, mechanical engineering: collection of scientific works*, 81, 111-118 [in Ukrainian].

[9]. Nakaz Derzhkommistobuduvannia «DBN 360-92. Mistobuduvannia. Planuvannia i zabudova miskykh i silskykh poselen» vid 17.04.1992 № 44 [Order of the State Committee for Urban Development «DBN 360-92. Urban planning. Planning and construction of urban and rural settlements» from April 17, 1992 № 44]. Retrieved from https://zakon.rada.gov.ua/rada/show/v0044481-92#Text [in Ukrainian].

[10]. Nakaz Ministerstvo okhorony zdorovia Ukrainy Pro zatverdzhennia Derzhavnykh sanitarnykh pravyla planuvannia ta zabudovy naselenykh punktiv (iz zminamy) №173 vid 19.06.1996 [Order of the Ministry of Health Protection of Ukraine About the consolidated sovereign sanitary rules of planning and forgetting settlements (out of wines) from June 19, 1996 № 173]. Retrieved from https://zakon.rada.gov.ua/laws/show/z0379-96#Text [in Ukrainian].

[11]. Nakaz Minzhytlokomunhosp Ukrainy Pro metodychni rekomendatsii iz zabezpechennia efektyvnoho vidvedennia poverkhnevykh vod № 470 vid 23.12.2010 [Order of the Ministry of Housing and Communal Services of Ukraine «Methodical recommendations for ensuring effective drainage of surface water». № 470-3 from Decevber 23, 2010]. Retrieved from https://zakon.rada.gov.ua/rada/show/v0470738-10#Text [in Ukrainian].

[12]. Nilova, O.V., & Moskalenko, Z.S. (2019). Ozelenenie kryish: otechestvennyiy i zarubezhnyiy opyit [Greening of roofs: domestic and foreign experience]. *Universum: Tehnicheskie nauki - Universum: Engineering Sciences*, 12 (69). Retrieved from http://7universum.com/ru/tech/archive/item/8450 [in Russian].

[13]. Ocheretny, V.P., Potapova, T.E., Kuzmina, D.M., & Sologor, V.M. (2017). Suchasna tendentsiia skorochennia ploshchi zelenykh nasadzhen v sviti [There is a current trend of speedy areas of greenery in the world]. *Suchasni tekhnolohii, materialy i konstruktsii v budivnytstvi - Modern technologies, materials and constructions in business*, 2, 69-76 [in Ukrainian].

[14]. Prilipko, T.V., Potapova, T.E., & Syromakha, O.V. (2015). Suchasnyi stan ta perspektyvy rozvytku landshaftno-rekreatsiinoi zony mista [The current state of the art for the development of the landscape and recreational zone of the place]. *Suchasni tekhnolohii, materialy i konstruktsii v budivnytstvi - Modern technologies, materials and constructions in business*, 1, 106-110 [in Ukrainian].

[15]. Seroshtan, L. (2015). Zelenyie kryishi. Landshaftnyiy dizayn ot kompanii «OAZIS» [Green roofs. Landscaping from the OASIS company]. Retrieved from http: //oasis-land.ru/zelyonyie-kryishi.html [in Ukrainian].

[16]. Shuvalov, V.M., & Saad, M.M. (2016). Mobilnoe ozelenie zdaniy [Mobile landscaping of buildings]. *Vestnik RUDN - RUDN Bulletin*, 2, 103-115 210 [in Russian].

[17]. Skabelkina, O.A. (2017). Sozdanie komfortnoy sredyi urbanizirovannyih prostranstv pri pomoschi «zelyonyih kryish» [Creation of a comfortable environment for urbanized spaces using green roofs]. *Vestnik landshaftnoy arhitekturyi - Bulletin of landscape architecture*, 11, 67-70 [in Russian].

[18]. Solonenko, V.I., & Vatamanyuk, O.V. (2017). Klasyfikatsiia vydiv vertykalnoho ozelenennia v landshaftnomu budivnytstvi [Classification of types of vertical landscaping in landscape design]. *Lisove ta sadovo-parkove hospodarstvo - Forestry and horticulture*, 5, 126-136 [in Ukrainian].

[19]. Tsurkina, S.K., Laketich, A., Laketic, N., & Korenkova, G.V. (2016). Osobennosti zelyonyie kryishi i ih mesto v sovremennom gorode [Features green roofs and their place in a modern city]. Pokolenie buduschego: vzglyad molodyih uchyonyih - *Generation of the future: the view of young scientists*, 3, 8488 [in Russian].

[20]. Zinchenko, A. (2015). *Zelenoe stroitelstvo: perspektivyi v Ukraine - Green construction: prospects in Ukraine.* Retrieved from http://www.researchclub.com.ua/journal/376 [in Ukrainian].

[21]. Berto, R., Stival, C.A. & Rosato, P. (2018). Enhancing the environmental performance of industrial settlements: An economic evaluation of extensive green roof competitiveness. *Building and Environment*, 127, 58-68 [in English].

[22]. Ferrans, P., Rey, C.V., Pérez, G., Rodríguez, J. P. & DíazGranados, M. (2018). Effect of Green Roof
Configuration and Hydrological Variables on Runoff Water Quantity and Quality. *Water*, 10, P. 960-977 [in English].

[23]. Heinze, W. & Schreiber, D. (1984). Eine neue Kartierung der Winterhärtezonen für Gehölze in Europa. *Mitt der Dtsch Dendrologischen Ges*, 75, P. 11-56 [in German].

[24]. Missouri Botanical Garden, 2020. Retrieved from: https://www.missouribotanicalgarden.org/ [in English].

[25]. Raunkiaer, C. (1934). *The Life Forms of Plants and Statistical Plant Geography*. Oxford University Press, London [in English].

[26]. Shafique, M., Kim, R. & Rafiq, M. (2018). Green roof benefits, opportunities and challenges. *Renewable and Sustainable Energy Reviews*, 90, 757-773 [in English].

[27]. SOU ZhKG 41.00-35077234.0018: 2009. (2009). Arrangement of surface water drainage on the territories of cities and settlements. Ministry of Housing and Communal Services of Ukraine [in Ukrainian].

[28]. Vovk, L.I. & Trofimchuk, Yu. A. (2018). Comparison of surface runoff volumes from typical residential districts of large cities, defined in accordance with the regulations of Ukraine. Retrieved from http://science.lpnu.ua/sites/default/files/journal-paper/2019/feb/15625/181820-3-9.pdf [in Ukrainian].

[29]. Teotónio, I., Silva, C.M. & Cruz, C.O. (2018). Eco-solutions for urban environments. regeneration: The economic value of green roofs. *Journal of Cleaner Production*, 199, 121-135 [in English].

[30]. The Plant List, 2020. Retrieved from 2020 http://www.theplantlist.org/ [in English].

[31]. Wilo - Use of rainwater. Reference manual, 2016. Retrieved from: https://atislab.ru/upload/doc/wilo/Brochure_rainwater_205x297_RU.pdf [in Russian].