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CONCEPTUAL DIRECTIONS IN REGIONAL MANAGEMENT OF MUNICIPAL SOLID WASTE SPHERE

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The problem of waste management is extremely topical for the regions of Ukraine. Landfills occupy valuable agricultural land resources. Unauthorized landfills cause special danger. At the same time, the issues of reducing contaminated lands area, their restoration and return to agricultural production are relevant for scientific research. The aim of our study was to argument scientifically the optimization model in municipal solid waste management sphere in the region aimed at balancing two economic and environmental criteria: economic damage for the environmental pollution and total expenses for the functioning of MSW handling sphere. The directions have also been determined for handling municipal solid waste in the context of realization of social, economic and environmental strategies and recommendations regarding the improvement of financial and economic support have been given. On the basis of the proposed model the optimal ratio of ecological and economic criteria for the development of waste management in Poltava region has been determined. It has been substantiated that the development of MSW management sphere should be aimed at resolving the priority issues of: providing environmentally safe MSW management at maximizing recycling and market development of recyclable materials, minimizing waste formation. Solving these problems in the region should be performed in accordance with the main directions that are proposed to be carried out in three phases. The model will create the basis for determining strategic development directions in the given sphere within the implementation of social, economic and ecological strategy of the regional development. The conducted research is the basis for developing scientific principles and practical recommendations for the formation of a system for the restoration of contaminated areas and their return to agricultural production in Ukraine.

Key words: *municipal solid wastes, sphere of waste management, region, strategy of development, financial and economic support, balanced development.*

КОНЦЕПТУАЛЬНІ НАПРЯМИ РЕГІОНАЛЬНОГО УПРАВЛІННЯ СФЕРОЮ ПОВОДЖЕННЯ З ТВЕРДИМИ ПОБУТОВИМИ ВІДХОДАМИ

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Необхідним елементом соціально-еколого-економічної рівноваги регіону є ефективне функціонування сфери поводження з твердими побутовими відходами (ТПВ). Проблема поводження з твердими побутовими відходами є надзвичайно актуальною для регіонів України. Звалища відходів займають цінні в сільськогосподарському значенні земельні ресурси. Особливу небезпеку створюють звалища твердих побутових відходів, які забруднюють землі сільськогосподарського призначення та створюють збитки довкіллю та сільському господарству. Водночас питання скорочення площ забруднених земель, утворення яких обумовлене звалищами відходів, їхнє відновлення і повернення до господарського обігу залишаються актуальними для наукового пошуку. Тому метою наших досліджень стало розробити оптимізаційну модель розвитку сфери поводження з ТПВ, спрямовану на збалансування двох взаємопротилежних критеріїв: економічного збитку за умови забруднення навколишнього природного середовища та загальних витрат на функціонування сфери поводження з ТПВ, а також створює основи для визначення стратегічних напрямів розвитку цією сферою в контексті реалізації соціально-економічної та екологічної стратегії регіонального розвитку. На основі запропонованої моделі визначено оптимальне співвідношення екологічних та економічних критеріїв розвитку сфери поводження з ТПВ для Полтавської області. Визначені стратегічні напрями розвитку сфери поводження з твердими побутовими відходами в контексті реалізації соціально-економічної та екологічної стратегії та надані рекомендації щодо удосконалення її фінансово-економічного забезпечення. Обґрунтовано, що розвиток сфери поводження з ТПВ має бути направленим на розв'язання пріоритетних питань щодо: забезпечення екологічно безпечного поводження з ТПВ, максимальної утилізації відходів та розвитку ринку вторинної сировини, мінімізації утворення відходів. Запропоновані етапи розв'язання цих задач на регіональному рівні. Обґрунтовано вибір оптимальних технологічних рішень на місцевому рівні, визначено альтернативні сценарії. Отже, проведені дослідження є основою для розробки наукових засад та практичних рекомендацій щодо формування старегій поводження з ТПВ для регіонального та місцевого рівня. Зокрема ці розробки мають стати основою подальших досліджень системи відновлення техногенно забруднених територій та повернення їх до господарського обігу регіонів України.

Ключові слова: *тверді побутові відходи, сфера поводження з відходами, регіон, стратегія розвитку, фінансово-економічне забезпечення, збалансований розвиток.*

Introduction

One of the conditions for sustainable territorial development is the social, ecological and economic balance in the region, which presents such a state of regional systems that provides economic growth, social stability and environmental safety in the region. The upsetting of this balance leads to the emergence of losses having different characteristic features: ecological, economic and social. An essential element of the social, ecological and economic balance in the region is effective functioning of municipal solid waste (MSW) management sphere.

The problem of achieving sustainable development in the region expands the sphere of human impact on the environment and intensifies the use of natural resource base, which inevitably brings the problem of rational using secondary resources to the fore. The region becomes a self-active economic agent, an active subject of competitive relations in the national and global economy. In a deeper sense, as V. I. Vernadsky noted in his studies, the solution of this problem requires creation of a new international order aimed at ensuring coordinated actions of the entire world community to avert environmental disaster, that is the transition to the noosphere development as intelligently managed co-development of human being, the society and nature, in which the satisfaction of vital needs of the population is made without prejudice for nature and future generations [1].

Today MSW management sphere in the region does not have systemic features, most likely it is a set of related but non-effective elements. Exactly under these conditions, the task of transformation of "a set of

elements" into the system becomes important through the development of MSW management system, covering all aspects of solid waste management: social, economic, technological, environmental and legal and their optimization. In this regard, the region can and should become the backbone "vehicle" of the state policy in this area and provide a purposeful wide range decision of the problems related to waste handling.

It should be mentioned that effective waste management problem has been solved to some extent in developed countries, in the first place in Europe. Though for example, "garbage crisis" of 2007–2008 in Naples showed that Western experts having great experience and scientific knowledge in the field of solid waste management cannot assert that the problem is completely solved [2]. As for Ukraine, primarily the sphere of waste management is in the state that has been inherited from the planned economy of the former Soviet Union. In recent years, a large number of works devoted to this problem has appeared in Ukraine, including the works by A. I. Bondar [3], V. Ye. Baranovsky, V. L. Piliushenko [4], O. V. Moroz, A. O. Sventykh [5], V. S. Mishchenko, G. P. Vyhovsky [6], V. V. Vambol [7], T. B. Hordovska [8], I. S. Yeremeev, S. V. Marchuk [9], C. Singh [10], H. Il, N. Gui, H. Jee [11], Y. Yunjiang [12], and others. However, despite the significant scientific principles established by these and other scholars, their attention is focused mainly on the technical and technological aspects of the problem. At the same time, there is lack of scientifically based methods and mechanisms of effective management in this field. Poorly substantiated here is also economic leverage. Besides, the issues focused on getting the desired effect from the use of the potential waste management sphere, as a part of the total potential of the region's economy and as a result of common actions of the participants of the wastes management sphere, have not yet received proper consideration up till now. That is, there is a need for comprehensive theoretical elaboration and practical improvement of MSW managing based on the parameters and the criteria of the region sustainable development in terms of spreading globalization.

The purpose of the research is to work out the optimization model of waste solid management aimed at balancing the two mutually contradictory criteria: economic damage for environmental pollution and total expenses for the functioning of MSW handling sphere. The model will create the basis for determining strategic development directions in the given sphere within the implementation of social, economic and ecological strategy of the regional development.

Materials and methods

The object of research is the field of solid waste management in the region. The theoretical and methodological basis of the study are the results of basic and applied research in the area of environmental security and regionalism, the provisions of the concept of sustainable development, scientific developments of Ukrainian and foreign scientists on the management of solid waste management. General scientific ecological and economic methods, in particular, became the methodological basis of the research monographic, comparative analysis, abstract-logical method, cartographic, and others [13–14].

Results and discussions

In Poltava region, the tendency of increasing MSW formation since 2000 has been observed, its composition, physical and chemical characteristics being diversified.

The annual MSW formation per capita has also increased (from 0.28 ton per person a year in 2005 to 0.56 ton per person a year in 2020). This is a common trend in Ukraine. Thus, the volume of the formed MSW in 2005 was 0.99 million m^3, in 2015 it was 1.1 million m^3, in 2020 it made 1.8 million m^3 (1.6 times more than in 2005). A considerable part of MSW (34.11 %) is formed in Poltava and Kremenchuk. The coverage of the Poltava region population by collecting and removing waste services is 60 % on the average, for urban population it is 90 % and for rural –25 % [15].

Comparing with 2005 the content of polymer waste, glass, paper and cardboard waste in MSW has considerably increased. The reason for this is, in the first place, the increase in packing material and its diversity. At the same time, the volume of utilization of MSW valuable fractions does not exceed 5 % on the average. So, in 2020, the amount of collected waste paper was 9697.97 m^3, of polymers – 8829.03 m^3, and glass – 2734.15 m^3 [15]. In fact, the collection of resource valuable fractions in the area of MSW collection is currently done in Myrhorod, the system is implemented in Kremenchuk, Khorol, Lubny, Poltava. Therefore, most of the resource valuable materials that make MSW are transported to the landfills and dumps and are sorted partially into separate groups. The amount of resource valuable components is not controlled.

Sorting out waste is not centralized and is done by hand with the assistance of other physical persons – enterpreneurs on a contractual basis. An important problem in this sphere is the off-gauge waste that cause the formation of unauthorized dumps [16].

Handling the collected MSW in Poltava region includes mainly the disposal method now. According to the State Administration of Environmental Protection of 1.01.2020, in Poltava region there were 566 authorized landfills and MSW dumps with a total area of 460.2 hectars, of which 131 have been certified and calculated. Today about 60 % of landfills do not meet the standards of environmental safety and more than 18.5 % are overloaded. The area of illegal dumps has also increased significantly. In 2005 the dumps were found with the total area of 18 hectars, in 2010 – 298 landfills with the area of 13.7 hectars, in 2019 – 411 dumps with the area of 60.2 hectars [17].

The carried out research in MSW handling sphere allows to single out the major problems in the field of waste handling in Poltava region. They are: particular constant increase in waste formation in the region, low utilization level of MSW landfills and the lack of correspondence of the majority of them to environmental health and safety standards, situations regarding waste handling in disorganized storage space is far from being satisfactory. On the whole, the situation in Poltava region in waste handling sphere is complex, it results in the loss of great amount of secondary materials and the shortfall of revenue from their utilization, the need for a permanent allocation of considerable amount of financial resources for building new waste grounds. The maintenance of the existing landfills and dumps in most cases create ecologically hazardous conditions in the areas of landfill.

The studies of current tendencies and the problems of solid waste handling in Poltava region testify to the necessity of working out the strategy of waste handling development sphere taking into account the interests of all stakeholders of this process [18-20]. Accordingly, the optimization model of waste solid handling development has been offered, it is aimed at balancing the two opposite criteria: economic damage from environmental pollution (D) and the total operation cost of the sphere (V):

$$V = \sum_{t=1}^{T} \left[\frac{1}{(1+i)^t} \cdot (A_t \cdot X_t + B_t \cdot Y_t + C_t \cdot Z_t + E_t + F_t) \right],$$

$$D = \sum_{t=1}^{T} (((\gamma \sum_{m=1}^{M} ER_m^A \cdot H_{factor_m}^{\ A}) + (\alpha \sum_{n=1}^{N} ER_n^W \cdot H_{factor_n}^{\ W})) \cdot X_t + ((\gamma \sum_{m=1}^{M} EL_m^A \cdot H_{factor_m}^{\ A}) + (\alpha \sum_{n=1}^{N} EL_n^W \cdot H_{factor_n}^{\ W})) \cdot Y_t),$$

where i – the discount rate;

t – functioning periods of MSW handling sphere per year;

A – processing costs, excluding profit from the sale of resource fractions (hryvnias/ton);

B – the cost of collecting and transportation of MSW (hryvnias/ton);

C –the disposal cost of MSW burial (hryvnias/ton);

X –MSW mass that goes to recycling (ton);

Y – MSW mass that is transported to the landfill (ton);

Z – total MSW amount that is removed, and the residue from recycling (ton);

E, F – the cost of putting the processing plant (station), waste ground into operation (hryvnias);

ER^A, ER^w – the emission of pollutant substances into water or the atmosphere in compliance with "recycling" technology (ton);

EL^A, EL^w – the emission of pollutant substances into water or the atmosphere in compliance with "burying" technology (ton);

H_{factor}^{A}, H_{factor}^{W} – coefficients of pollutants relative harmfulness that enter the atmosphere and water;

γ, α – constant values that are determined considering inflation rate (hryvnias/ton);

m, n – the amount of pollutants entering the atmosphere and water.

On the basis of the proposed model, the optimal ratio of environmental and economic criteria for the development of waste management in Poltava region (Fig. 1) has been determined. The development of MSW management sphere should be aimed at resolving the priority issues of: providing environmentally safe MSW management at maximizing recycling and market development of recyclable materials, minimizing waste formation. Solving these problems in the region should be performed in accordance with the main directions that are proposed to be carried out in three phases (Figure 1-2).

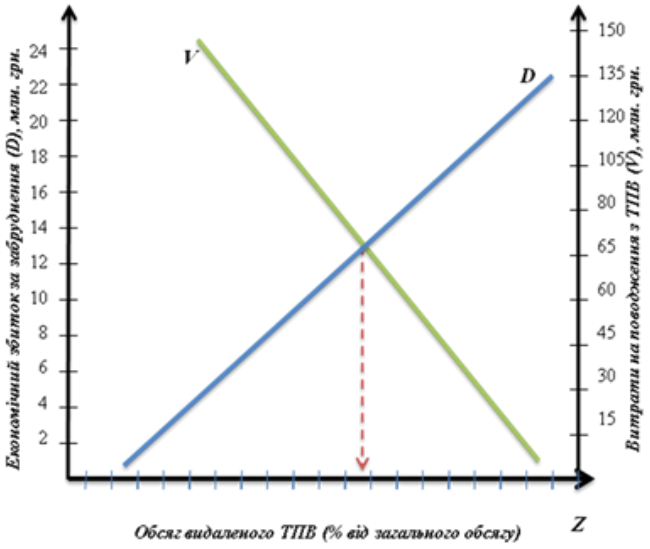

Figure. 1. Optimal ratio of development criteria in MSW sphere in Poltava region

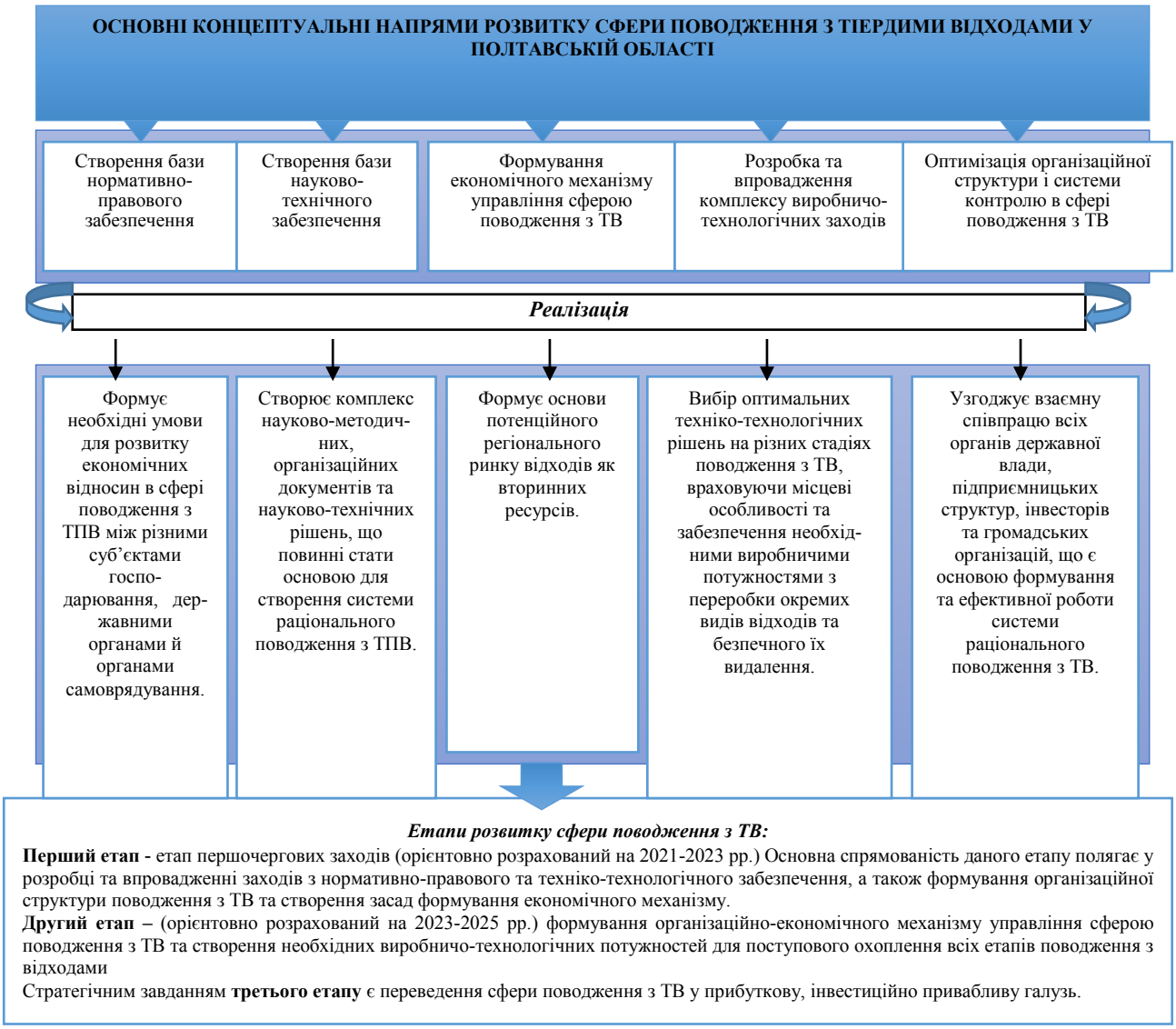

Figure 2. The main strategic development directions of MSW handling sphere in Poltava region

According to the defined development directions of MSW handling sphere the following urgent problem remains: a wide application of financial and economic provision measures. But the vector of using these measures should have innovative character for creating powerful production potential from secondary raw materials; ecological safety and social growth must be promoted.

Otherwise, the financial resources coming into the sphere of waste management will compensate the losses from irrational management in this sphere and will support uncompetitive model of production organisation. Considering the requirements to the local development policy of MSW handling sphere, introducing the system of priority measures of financial and economic supply of optimal functioning and developing the sphere as well as the Resolution of EU Council "The Strategy of the European Union in Waste Management" it is necessary to strive for the realization of tactical goals: minimization of MSW formation, their maximal possible utilization and safe removal (Fig. 3).

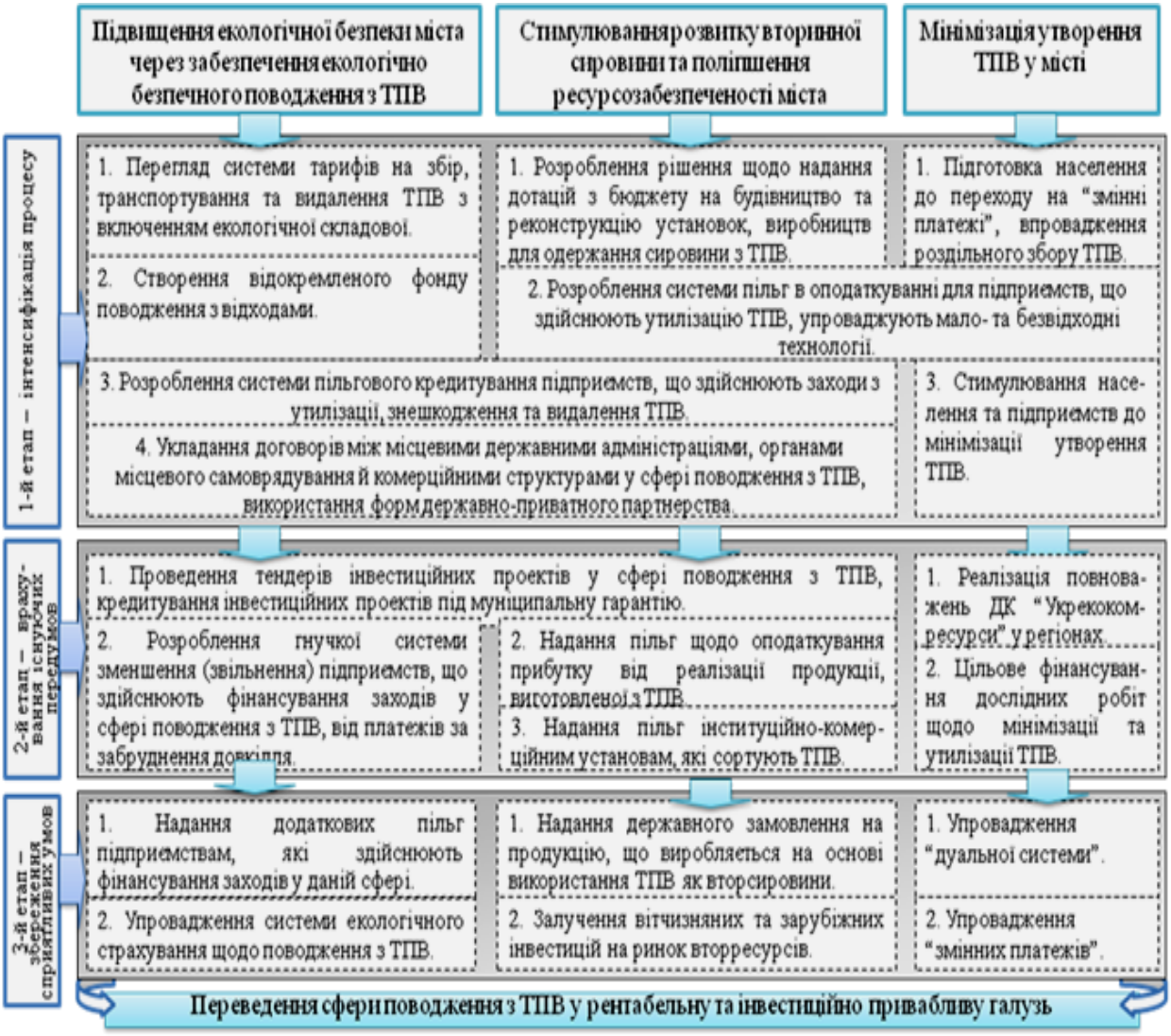

Figure 3. Differential approach to the selection of financial and economic measures providing the development of MSW sphere

The mentioned measures will have to be implemented in 3 stages: stage I – immediate measures aimed at intensifying the process, stage II – intermediate measures aimed at taking into account the existing conditions, stage III – long-term measures aimed at preserving the favorable conditions in certain target areas.

The choice of optimal technological solutions is involved in research with the studying the regional issues in this area. Scientists [20] conducted a number of investigations and identified alternative scenarios for the restoration of these areas on the example of Sencha village council (Fig. 4).

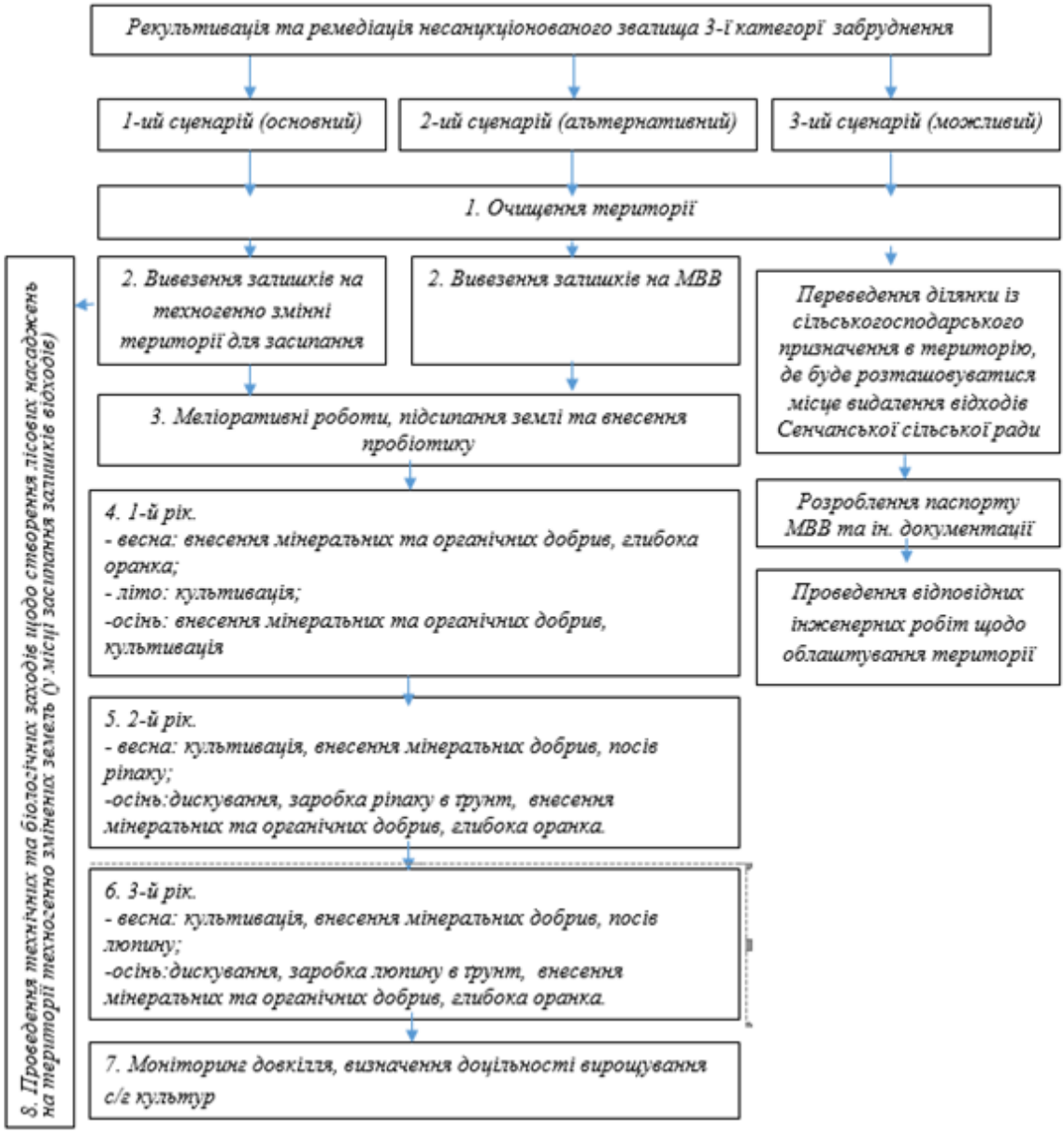

Figure 4. Possible options for reclamation and further use of the landfill [19]

Conclusion

The development strategy of MSW sphere allows to form an effective integrated waste management system that will enable to achieve the following results: creating legal, scientific and technical basis for the rational and safe waste management, developing economic instruments aimed at forming and developing waste market as secondary resources; improving organizational infrastructure for sustainable waste management; introducing a single system of accounting, control and management of MSW streams and establishing the system for monitoring the environmental state of solid waste disposal places; providing environmentally safe disposal of solid waste and creating trends for reducing "final wastes", which are transported to the landfill; reducing unauthorized removal of solid waste and economic loss for the solid waste pollution; minimizing MSW formation; increasing waste utilization coefficient and investments in this given sphere, introducing separate collection system of solid waste; constructing waste sorting stations for the development of secondary resources market; providing population with services for collecting waste and with technical means of solid waste removal; creating capacities for the utilization of organic waste at composting plants.

Areas of further research. The conducted research is the basis for the development of scientific principles and practical recommendations for implementing the strategies for solid waste management at the regional and local levels. In particular, these developments should become the basis for further researching the system of the restoration of industry-related contaminated areas and their return to economic circulation in the regions of Ukraine.

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