DOI: 10.31520/2616-7107/2022.6.2-5 *ISSN 2616-7107*

UDC 625.75
JEL: L74, Q53, M11, O32

CONSTRUCTION WASTE MANAGEMENT FOR IMPROVING RESOURCE EFFICIENCY IN THE RECONSTRUCTION OF WAR-DESTROYED OBJECTS

Dzintra Atstāja
PhD., Professor,
BA School of Business and Finance,
Riga, Latvia
E-mail: dzintra.atstaja@ba.lv
orcid.org/0000-0002-9411-7212

Viktor Koval
Doctor of Economics, Professor,
National Academy of Sciences of Ukraine,
Kyiv, Ukraine
E-mail: victor-koval@ukr.net
orcid.org/0000-0003-2562-4373

Māris Purviņš
PhD in Business Administration,
BA School of Business and Finance,
Riga, Latvia
E-mail: maris.purvins@ba.lv
orcid.org/0000-0002-3199-3581

Jānis Butkevičs
BA School of Business and Finance,
Riga, Latvia
E-mail: janis.butkevics@ba.lv
orcid.org/0000-0002-5610-3135

Inesa Mikhno
PhD in Economics,
National Aviation University,
Kyiv, Ukraine
E-mail: inessa.mihno@gmail.com
orcid.org/0000-0003-3661-1965

Received: April 28, 2022
Accepted: June 20, 2022

DOI:10.31520/2616-7107/2022.6.2-5

Introduction. Social and hostility conflicts in Ukraine have caused global changes and deterioration of the ecological and economic situation in numerous countries, resulting in higher risks to the population and giving the impetus to create a new innovative, cultural, and technological society. Greening principles, which have become popular in developed countries, are impossible to implement without the coordinated cooperation of states and their genesis in accordance with joint programs and development vectors. As a result, an increasing number of foundations and grants have recently been established to support eco-friendly products and solutions, assist in their adoption, and develop the organizational structure of an efficient system based on green economy principles, thereby improving global standards and regulations.

Aim and tasks. The aim of the study is to develop a methodology for planning the modernization of constructed infrastructure, better resource efficiency, and reduce waste in the reconstruction of war-destroyed objects**.**

Results. The best option for post-war waste disposal is the construction of mobile waste recycling complexes based on fractional waste recycling and its secondary use in further reconstruction of Ukrainian infrastructure, which after final restoration will be moved to safe areas around large cities and used as stationary waste recycling plants. To improve the environmental situation, one suggests building landscaped parks that will operate due to state-of-the-art technologies (obtaining natural energy, etc.) and creating a system of harmonious combination of anthropogenic infrastructure and natural areas, businesses, and public accessibility.

Conclusions. The key goal of the reconstruction of Ukrainian territories is to establish an innovative, sustainable, and safe system of social existence by increasing the efficiency of actions and methods based on the principles of rational environmental management and increasing responsibility. When calculating the cost of the restoration of Ukrainian territories, one should take into account additional expenses caused by hostilities, which will be further considered as a stress factor having a cumulative negative impact and leading to disastrous consequences that can be estimated in monetary equivalent as the sum of the price of restoration of components of the ecological, economic, and social system under the effect of a set of factors resulting in negative changes and damages.

Keywords: post-war restoration, construction waste, waste recycling complex, resource efficiency.

1. Introduction.

The establishment of a sustainable society in crisis conditions is impossible without realizing the consequences of human activities and the preservation of the ecosystem that has been recently suffering from an increasing negative anthropogenic impact. In Ukraine and European countries, the shift to a responsible economic system aimed at reducing negative effects, rationalizing natural resources and improving the national economic situation has a positive trend due to the high level of public culture and wide opportunities for promoting the principles of green economy via information resources, educational programs, the Internet, as well as by individuals interested in the establishment of an eco-friendly society.

When the hostilities end, Ukraine will develop a new system of balanced environmental management that can be implemented by transforming the existing outdated technological processes, demolishing old industrial and residential buildings, and creating brand-new locations that comply with the environmental legislation (Tambovceva, Urbane, & Ievins, 2020).

To develop efficient tools for reconstructing Ukraine and adopting the green economy, one will need the systemic formation of the legislative framework, modification of market and legal mechanisms, development of market incentives and guidelines, enhancement of international cooperation, adjustment of consumer demand for eco-friendly goods and services, constant support of government and business structures, transparency and correctness of analytical data and public awareness of the implementation of rational environmental management.

The change in the marketing policies for many manufacturers should also become the foundation for the transformation of society (Hanson, 2018). The development of marketing injections and strategies is now widely used in Europe to adopt the green economy and has a positive outcome, while the same process in Ukraine requires additional financial resources because of the war and economic problems that have become paramount, as well as the issue of survival prevailing over the indicators of life quality improvement and the creation of a comfortable environment.

The main stage of reconstructing and restructuring the current economic mechanisms in Ukraine and European countries is digitalization, which has sped up changes and public awareness, creating a new class of capital and resource owners, simplifying substantially the resource-saving promotion technology and providing new opportunities for the greening of life processes and the production of goods. In turn, the issue of restoring the outdated or destroyed by the war infrastructure, organizing the process of reconstruction, and transforming society's thinking from costly to safe (taking risks into account) remains unsolved (Yuan, 2013; Noaman, & Alsaffar, 2019).

Thus, the issue of establishing a socially and environmentally focused society is still in the process of formation in developed countries and is at the initial stage of being introduced in developing countries, including Ukraine, which now requires the implementation of the restoration concept using financial resources from international financial institutions. Another relevant and unsolved problem is the accumulation of waste, the amount of which is increasing dramatically in the face of military operations, turning into a global challenge for humanity because of its having no local impact as previously thought.

2. Aim and tasks.

The aim of the study is to develop a methodology for planning the modernization of constructed infrastructure, better resource efficiency and reducing waste in the reconstruction of war-destroyed objects, which are the key goals of changes that are possible in the case of the coordinated work of neighboring countries due to the indirect impact of ecological and other factors on social life in general, namely the domino or chain effect, with changes in certain indicators in one territory affecting the territory of another country

3. Methodology.

Comparing waste management in Ukraine and Latvia (pre-war), another post-Soviet country, there is a lot of similar data indicating the establishment of circular economy in these countries and the large number of difficulties faced by society (Table 1). The construction waste structure shows the predominance of unstructured waste, which should be sorted and subjected to preparatory for recycling.

Table 1. Construction waste structure in Latvia in 2022.

Incoming CW classes	Waste class	Amount of waste	AVER	Total, tones
		100.00%	Per month	8 323
Sand (Rigas Siltums PowPlant)	100124	*1.20%*	34	101
Concrete	170101	*11.90%*	330	991
Bricks	170102	*9.00%*	251	752
Tiles, roof tiles, ceramics	170103	*0.00%*	0	0
Concrete, bricks, tiles, ceramics mix, not responding to 170106 class	170107	*18.30%*	509	1 526
Wood	170201	*0.60%*	17	51
Glass	170202	*0.00%*	1	1
Asphalt	170302	*0.50%*	13	40
Soil and bricks	170504	*0.20%*	6	18
Construction waste not responding to 170901, 170902 and 170903 class	170904	*54.60%*	1 516	4 548
Wood (Ikškile, Kaparāmuru MWCP)	200138	*0.00%*	0	0
Biological waste (BIO)	200201	*0.00%*	0	0
Wood furniture (Ikškile, Kaparāmuru MWCP)	200307	*3.60%*	99	296

Source: Official statistics of Latvia (2022).

Therefore, the construction of modern waste recycling complexes is a challenging systemic task that should have a clearly organized organizational structure with the adaptation of technologies to the specific situation. The integral component of developing the waste management technology is the organizational structure of the project, its stages, and rational and proper administration, which will improve the lives of the Ukrainian population. Key stages of developing further waste actions are based on the steps shown in Figure 1.

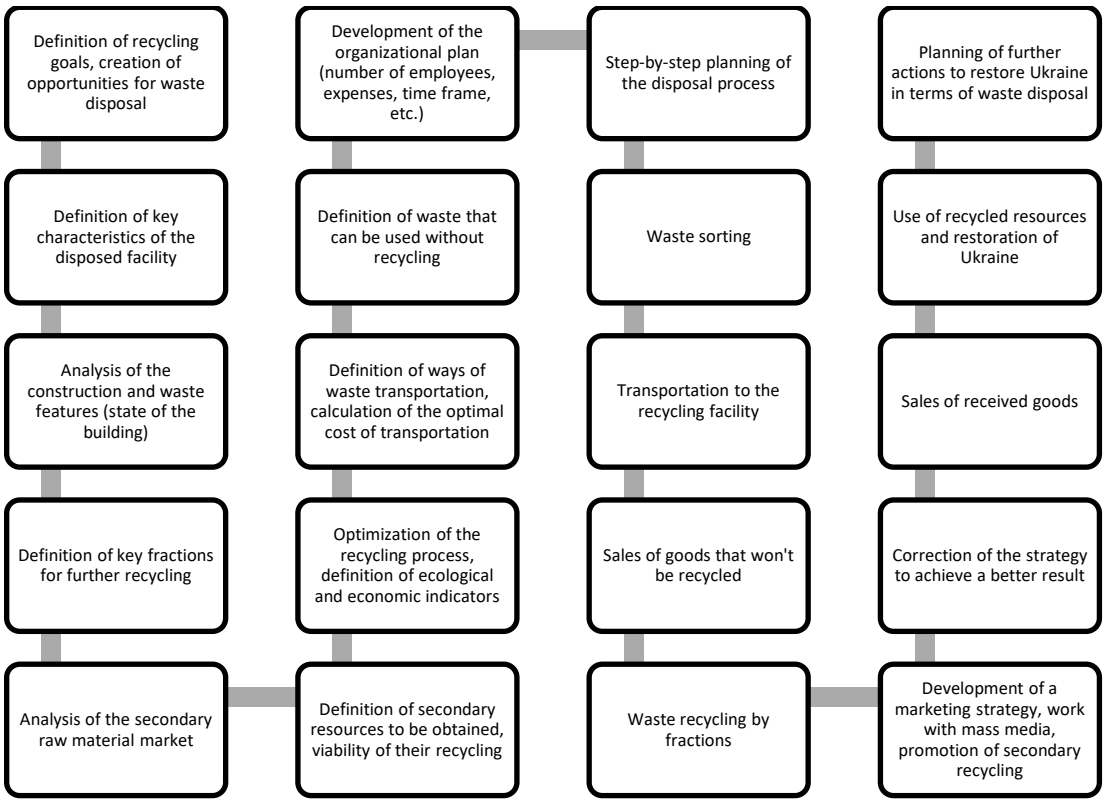

Fig. 1. Waste management strategy during Ukraine's restoration after military operations.

Figure 1 shows that waste disposal is a multi-step process that should be adjusted to every type of available waste at its maximum possible recycling. The concepts that would be implemented include zero waste, green economy, resource management, constant advancement of production and goods, intensification of production, maximum automation of the recycling process, and digitalization, which would ensure the permanent development and encourage investors and foreign partners to cooperate and finance the project.

To implement the project, one requires the following number of departments to perform a range of functions to adopt the waste disposal process (at least 1 person per department) (Liu, & Wang, 2020):

1. Director of the enterprise, representatives of external audit.
2. Innovation and performance improvement department (scientific department).
3. Financial and economic department, planning department.
4. Legal department (as well as to adjust waste management legislation).
5. Environmental audit and innovation department.
6. Marketing department, mass media department, product sales department.
7. Investment department (involvement of investments, grants, etc.).
8. Production department (sorting + disposal).
9. Department of service and improvement of working conditions of project participants.
10. Logistics department (+ mapping).
11. Analytical department.
12. Advanced training department + HR department.

One suggests using a flexible organizational structure of the enterprise that can be adjusted to certain features of each region of project implementation, minimizing the administrative composition of the team, correcting staff functions, as well as ensuring staff professional advancement and communication with foreign colleagues to improve the project performance.

The project will not only result in the improvement of environmental and economic indicators in Ukraine, country's reconstruction and rationalization of resources, but it will also involve the population in the restoration process by promoting waste disposal, attracting investments, training the professional disposal staff, resolving systemic problems in Ukraine, providing jobs, restoring the economy after the global stress, adopting cutting-edge waste management tools and innovations, involving young people in the greening of social and manufacturing processes, establishing the recycled materials market, developing state-of-the-art models (Zoghi, & Kim, 2020).

Let the construction waste recycling plant consist of mobile modules that can be transported to the territory of other plants if necessary (Yuan, 2013). The minimum number of modules and their technical characteristics are shown in Table 2. basic modules for construction waste recycling can be used to recycle different types of materials, upgraded according to the fraction and compounded according to the needs, which will substantially increase the efficiency of the waste recycling complex.

The total cost of the main equipment will be approximately 1 million USD. With the normative number of 50 workers per shift, 3 shifts per day (1 work shift per 3 days) and the average wage of 1000 USD per month, the labor costs will be about 450 thousand USD. Approximate costs for utilities will be about 2500 USD. Taking into account taxes (minimum VAT of 20%) and the cost of installing equipment, transportation and adjustment of production, the initial cost of building the mobile waste recycling complex will be about 2.284 million USD.

Ukraine requires at least 12 waste recycling complexes to be located in regions most affected by the war, which initially cost 27.4 million USD in total. It is an additional burden on the budget of Ukraine in the recovery period. Therefore, we offer to take advantage of foreign investors and the availability of grants for the reconstruction of Ukraine, namely assistance to Ukraine from the USA, where the expense structure includes 9 billion USD for additional economic and technical aid to Ukraine.

Table 2. Basic module mobile systems of construction waste recycling and their characteristics.

Fraction for recycling	Equipment	Capacity	Received material	Module price
Concrete, stones, reinforced concrete, expanded clay, scrapped paving tiles	Concrete sorting and recycling machine	120 t/hour	Crushed concrete	500.000 USD
All types of metals	Fractional metal recycling machine	7 t/hour	Metal alloy, metal sheets, crushed metals by fractions	90.000 USD
Wastes of wood, cardboard, paper	Wood waste shredding equipment	1,5 t/hour	Fuel materials (briquettes, granules), chipboard, compost	110.000 USD
All types of dry waste	Dust and chip extractor	6000 cubic meter / hour	Purified waste	1.000 USD
Glass by color	Glass recycling line (cleaning / shredding /packaging)	5 t/hour	Sorted glass scrap according to specified parameters	40.000 USD
Plastic waste (synthetic materials)	Polyethylene film recycler/plastic recycler/plastic bottle washing line	4 t/hour	Flex, film, etc.	50.000 USD
Bitumen waste, roofing felt, oil sludge	Bitumen waste cleaning and recycling line	10 t/year	Roofing materials, purified, pressed bitumen, raw material for road construction, bituminous powder, mastic, primer	140.000 USD
All types of waste	Sorting station	400,000 t/year	Sorted waste	170.000 USD

Source: Aliexpress (2022), Andritz (2022), HAAS Recycling Systems (2022), Zbgroup (2022).

While analyzing the efficiency of building the waste recycling complex to restore the infrastructure of the destroyed populated areas caused by hostilities, one should take into account the reduction of risks while improving the environmental condition of life and enhancing quality of life (Lauritzen, (1998; Ding et al., 2018; Spišáková, Mésároš, & Mandičák, 2021).

4. Results

In addition to the destruction of infrastructure, military operations result in fires, which are a source of dangerous emissions into the atmosphere, the burning of topsoil (at least 6 cm), the destruction of the ecosystem, the death of the biocenosis, the recovery of which will require decades and funds to clean up the territories and artificial restoration (Islam et al, 2019).

Expenses for the recovery of the natural environment, including decontamination of hazardous emissions and waste disposal, can be calculated using the sum of all financial expenditures required to bring the ecosystem and infrastructure to the minimum zero point (previous state) and, in the desired scenario, to the upgrading of all systems according to cutting-edge solutions and the improvement of the ecological and economic state of the region (Zoghi, & Kim, 2020). The coefficient of additional costs can be calculated by formula 1:

$$V_i = \frac{\sum_{n=1}^{N} V_{ni}}{\sum_{n=1}^{N} V_{pr}} + \frac{\sum_{n=1}^{N} Z_{ni}}{\sum_{n=1}^{N} Z_{pr}} \quad (1)$$

Where *Vni* is the sum of expenses for the recovery of the natural environment and infrastructure of the region, *Vpr* is the sum of expenses for maintenance of the state of the recovery of the natural environment and infrastructure of the region without risk situations (before the war), *Zni* are healthcare expenses, social benefits, death or insurance expenses, *Zpr* are healthcare expenses, social benefits, death or insurance expenses in the control risk-free period (before the war), n are analyzed time intervals (for Ukraine – day, quarter, year).

Following the results of this coefficient, we can compare the losses of certain regions for a certain period in case of the risk situation (war), which will allow us to allocate available financial resources for the recovery, develop the plan of further actions and the region development program.

For example, one spent 1 million USA per hectare to build Natalka Park in Kyiv. It is a relatively high expenditure (also due to the stealing of the budget), however, it is efficient, as the park is comfortable and can become a model project for the further reconstruction of Ukraine. Expenses for infrastructure construction in other regions will be reduced by the coefficient stipulated by the Ministry for Communities and Territories Development of Ukraine (2022), which means that the cost of building similar facilities in different regions will be lower than in Kyiv proportionally.

To restore the natural and anthropogenic modified infrastructure of populated areas, taking into account data as of August 1, 2022, and formula 1, one needs at least 6*109 USD, i.e., 6 billion dollars, which can be divided into several tranches during the construction year.

The first priority is waste disposal, the construction of houses, then the infrastructure restoration according to the clearly defined plan, then the implementation of economic and environmental development projects based on the principles of green economy.

First off, one should start reconstructing the most destroyed territories of Ukraine (eastern part), moving northwestward, while introducing transparency and accountability of funds, creating electronic accountability and general access to reconstruction results, involving local communities in the development of plans, correction of actions, control over all construction stages and financial flows, as well as advancing the existing online services based on the E-Governance for Accountability and Participation Program. If analyzing waste recycling in Ukraine and comparing these figures with other countries, we can see a significant difference and the reduction in recycling rates within the past years (Fig. 2).

Comparing the level of recycling per person in Ukraine with Poland bordering with Ukraine and Germany, which was one of the first countries to adopt the circular economy, we could see that it was already problematic before the war and led to the accumulation of waste, constant destruction of the ecosystem, and the accumulation of negative externalities. By the 2000s, Ukraine still had the remnants of secondary recycling that had functioned since the Soviet Union. After the independence, their number was constantly decreasing, increasing the amount of waste going to landfills, most of which were built illegally and functioned as part of the shadow economy and unaccountable enterprises.

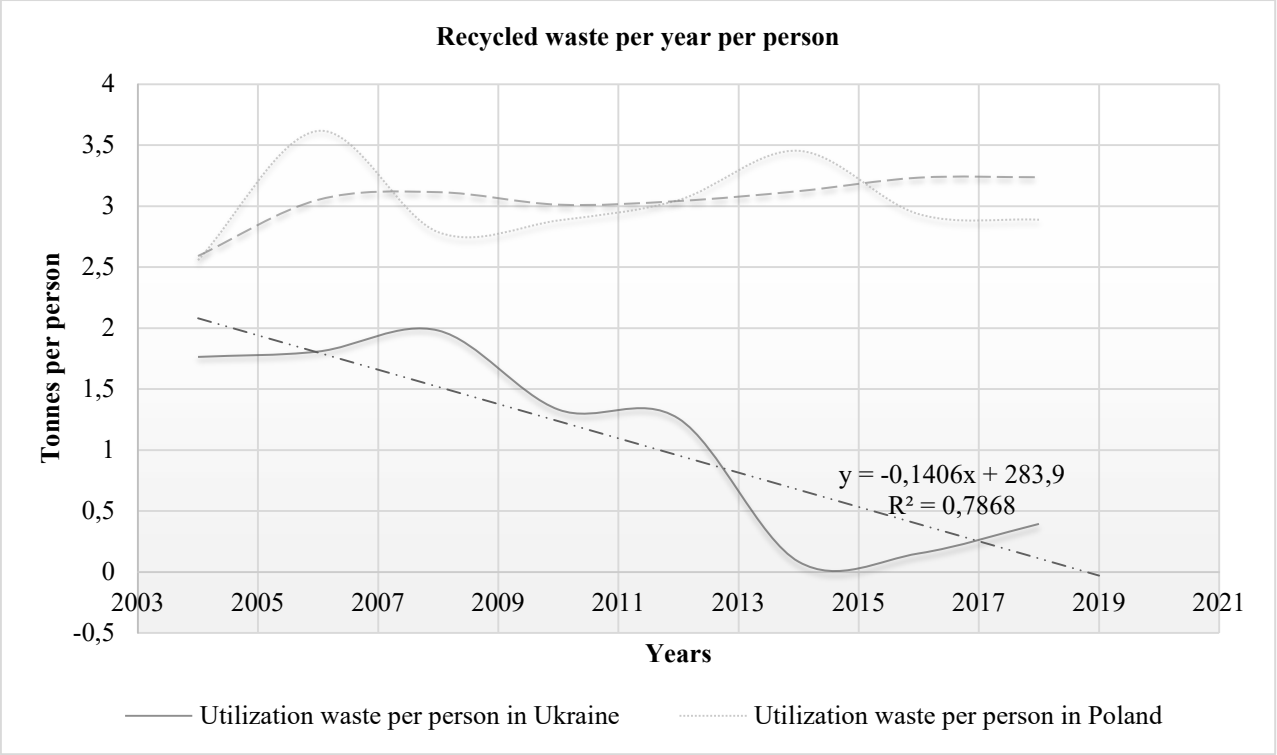

Fig. 2. Dynamics of waste utilization per 1 person according to countries [3, 4]
Source: Eurostat (2022); State Statistics Service of Ukraine (2022).

Figure 2 shows the increasing level of recycling per 1 person at the time interval in Germany, which also has been implementing the principles of green economy since 2018, advancing recycling technologies, reforming the legislation and encouraging all segments of the population to secondary recycling.

Analyzing the condition of secondary waste recycling in Poland, we can see a less stable situation but the increasing level of waste recycling with the adoption of the green legislation effective in European countries. The establishment of new plants and the increase in their capacity took place in 2006 and 2014, which also affected the general level of utilization, where the export and import of wastes of almost all fractions was allowed until 2021.

If analyzing expenses for environmental preservation in the pre-war period, the situation in Ukraine is problematic as well compared to European countries. The analysis of environmental protection investments in Ukraine also shows the insignificant decrease in expenses in the euro equivalent, negatively affecting problems that have been constantly accumulating and increasing their negative impact over the years, while the natural environment has not had time to recover with the constant increase in anthropogenic impact (Fig. 3).

The shift to the green economic system requires a wide spectrum of tools primarily based on stability, predictability, responsibility, investments, governmental support and interest, environmental and economic guidelines, which will increase social welfare and positively affect the ecosystem.

Figure 3 shows that developed countries (Switzerland, Germany) have been constantly increasing environmental protection investments at the time interval. The calculation was made per 1 person, as the negative impact of each person causes ecosystem changes, i.e., anthropogenic environmental changes directly depend on the number of people living in the territory of the given country.

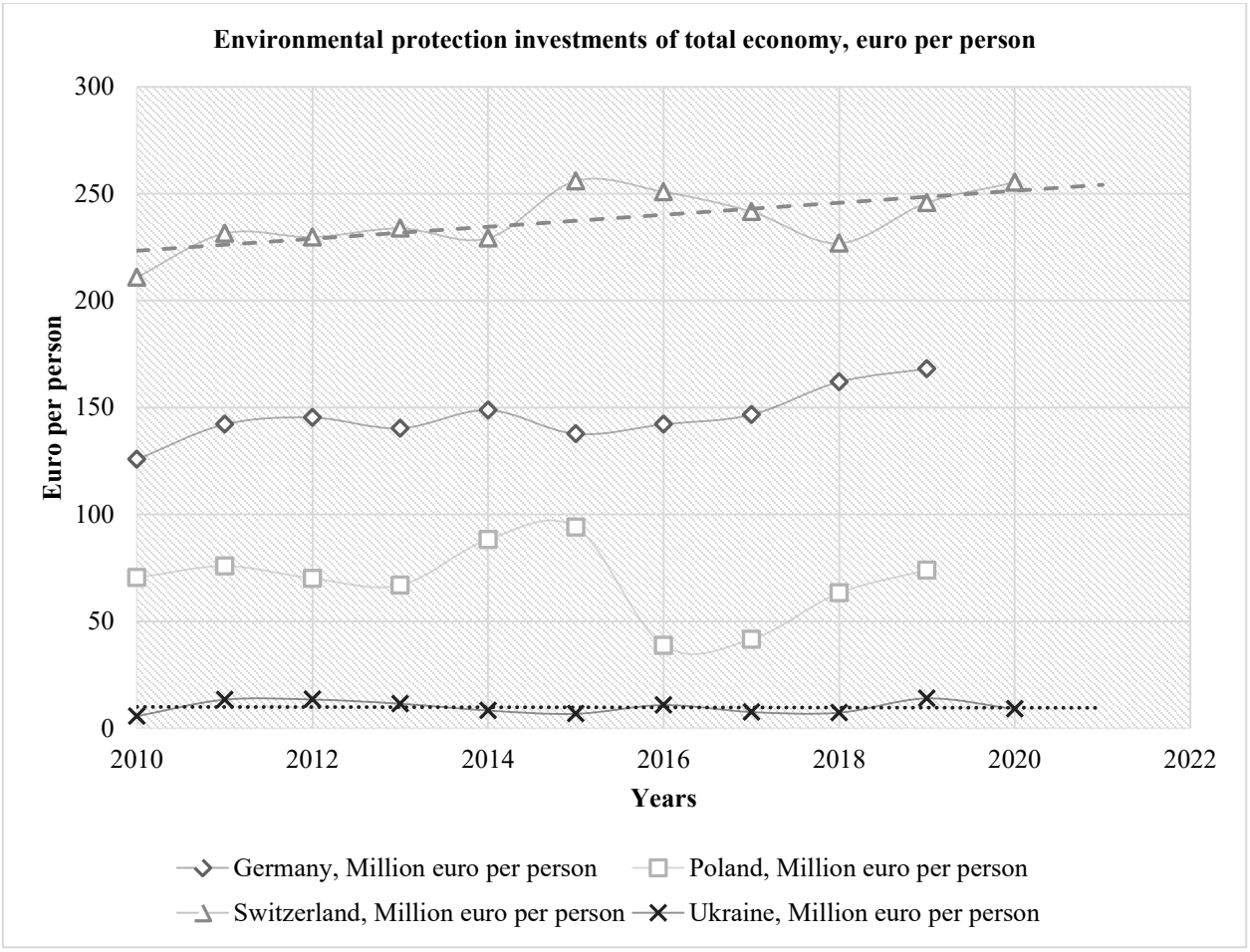

Fig 3. Dynamics of environmental protection investments per 1 person in different countries.
Source: Eurostat (2022); State Statistics Service of Ukraine (2022).

A specific feature of Poland bordering with Ukraine is volatile investments in ecosystem preservation (increased dispersion at the time interval) compared to the studied countries (Germany, Switzerland), which indicates the establishment of the ecosystem protection system and different visions of the authorities regarding the problem, but the amount of investment is significantly higher than in Ukraine (10 times higher on average), contributing to the adoption of circular economy in Poland and implementation of European values and legislative changes.

At the same time, European countries feature the targeted use of funds and their greater efficiency than in Ukraine where corruption mechanisms and lobbying of private interests (shady schemes, lobbying for rewards) worsen the situation and make the problem of insufficient investment in environmental protection more global and less controlled, which also lead to the destruction of the ecosystem in neighboring countries and the indirect negative impact of the world's territories on 6971114 sq.km of the center of Ukraine (Marianivka village, Cherkasy region).

Figure 3 shows that the accumulation of negative ecological trends in Ukraine and society's reluctance to significant changes occurred before the war, while military operations finally led to the destruction of the ecosystem and caused immediate actions to restore the environmental and economic potential of Ukraine, retransform the whole economic system and adopt new principles and methods based on positive European experience and the green economy that should be implemented in most populated areas while reconstructing Ukrainian territories.

Another foundation for further reconstruction in Ukraine will be the concept of sustainable architecture introduced in developed countries.

It is a combination of environmental, economic and social focus of all implemented projects, as well as the reconstruction complexity and enhancement of safety. Adaptation to risks and the possibility of autonomy of each project during the reconstruction will contribute to the most efficient use of available resources and rapid response to stress factors. Therefore, the availability of mobile waste recycling complexes can substantially speed up the resource dependence of Ukraine and promote rapid recovery from crises.

Restoration of Ukraine's ecological potential will take decades, but the adoption of state-of-the-art technologies and systemic restoration operations can speed up these processes by neutralizing negative environmental, economic and post-war factors, harmonizing and reconstructing the infrastructure using eco-friendly projects, which will allow implementing the principles of energy efficiency and increasing the productivity of the population by improving living conditions.

If financial resources are available, one suggests using carbon fiber (carbon plastic) obtained from waste by carbonization (creation of carbon threads) and graphitization in the future production. To minimize the cost of the construction, it is desirable to use other composite materials resulting from construction waste recycling.

A large number of plantings on the streets and comfortably arranged paths will increase walking among the population, reducing the burden on vehicles and the environmental impact of their operations. Thus, it is viable to develop the plan of populated area reconstruction, taking into account natural environments that can be located in most places of common use.

Every Ukrainian should feel part of the natural system that creates their future and accelerates the development, environmental friendliness and technological capacity.

To improve the visualization of ecological and economic damages caused by hostilities in Ukraine, the planning and further actions, one offers to advance or develop cutting-edge maps of Ukrainian infrastructure destructions.

Currently, Ukraine has a lot of modified online maps based on the available data (Fig. 4), but all of them require advancement or addition.

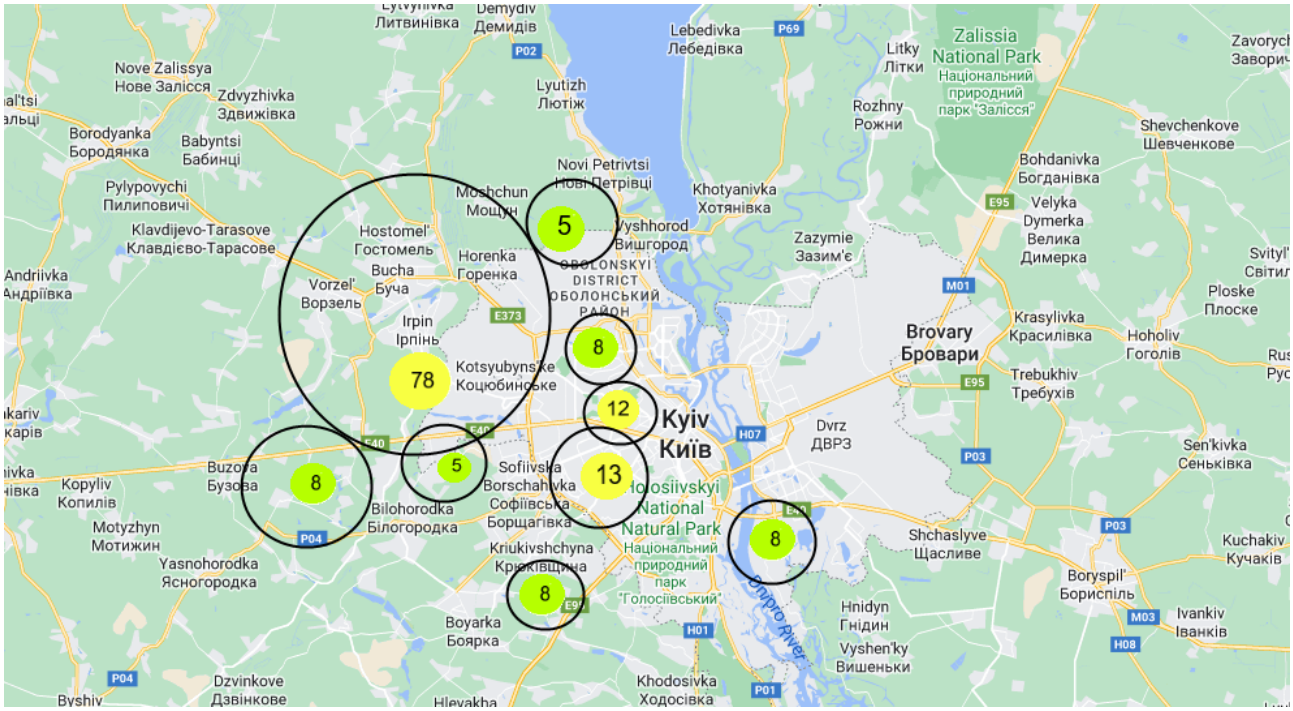

Fig. 4. Map of Ukraine's destructions caused by hostilities with advancement tips.

Source: Map of Destructions (2022).

Therefore, the best option would be to use Google Earth maps with the ability to switch to a real-time map using satellite data and the availability of analytical tools to explore information at the time interval. Besides, one suggests supplementing the map with tools for adding the destroyed facility by the population of Ukraine with subsequent processing of information by the analytical center of domestic waste recycling and restoration of Ukraine to create operational actions to neutralize the damage and develop a map of reconstruction of Ukrainian territories according to the adjusted plan and the capacity of mobile waste recycling complexes.

Figure 4 shows that available maps of destructions require upgrading to better regulate the current situation. At the same time, we can see the increase in the ecological load and the ecosystem destruction, having a higher price than officially calculated by the Ministry of Ecology and Natural Resources of Ukraine because of the constantly growing impact and increasing stress factors.

If considering the cost of a single missile launch from the Russian territory, we can see significant deviations in impact indicators and price characteristics. The approximate price of one missile (Tochka-U) is 3000 USD (Forbsua, 2022) and can be higher due to the cost of launch itself (transportation of soldiers, their training, auxiliary materials, etc.) , and the area of impact will be 28 sq.km. in case of launching a single missile, i.e., the cost of hitting one square kilometer ranges from 107 USD if taking into account only the price of one missile.

In practice, the cost of rebuilding one square kilometer is at least 47,000 USD (the average indicator of reconstructing infrastructure facilities of the populated area according to formula 1), which is much higher than the losses of the country suffering from the explosion.

Stress factors result in poorer labor productivity of the country's population and deterioration of public health, which is undesirable with the accumulated stress during military operations and the large number of social needs for the construction of modern, safe and successful Ukraine. When calculating the cost of stress factor impact on the object, it is necessary to take into account the following indicators:

Z – increasing expenses related to poor health of the studied living beings (l) suffering from the negative impact,

S – the cost of deaths calculated as the price of life insurance in the given populated area per total number of cases in the neighborhood of influence (m),

B – the cost of disposal, recycling and reconstruction of affected infrastructure facilities out of secondary raw materials,

E – environmental losses in the neighborhood of influence (the cost of ecosystem restoration in the neighborhood of influence, including soil, water resources, biosystem, air purification, etc.),

D – expenses for basic and auxiliary materials to be used for reconstruction (including the construction of mobile waste recycling complexes),

R – expenses related to the increase in wages for the staff working on the restoration of territories, taking into account the amount of work-hours required to implement the restoration project,

I – expenses for innovative systems, improvement of safety systems and living standards of the population,

A – total administrative expenses, expenses for consulting services for project development, expenses for transporting the necessary equipment, labor means and staff to the recovery site,

$dk(t)$ – exposure time coefficient (accumulation of the stress factor impact) that increases restoration expenses.

$$Str = \frac{(\sum_{l=1}^{L} Z + \sum_{m=1}^{M} S + \sum B + \sum E + \sum D \sum_{g=1} R + \sum I + \sum A)dk}{dt} \quad (2)$$

Thus, the impact of a particular stress factor is a complex value consisting of the sum of the values of parameters negatively affected by the stress factor (while implementing the project on the restoration of destroyed territories).

Total expenses for the restoration of destroyed territories will become one of the components of the establishment of green economy in Ukraine, which can be calculated as the total cost of introduced changes in the establishment of the new economic system that will substantially enhance the quality of public life, as well as lead to the first positions in the rating according to the Gini coefficient, quality-of-life index, business transparency index, stability index, Environmental Performance Index, Knowledge Economy Index, Happy Planet Index, Global Innovation Index, Global Peace Index, Crime Index by Country.

The above-mentioned results can be achieved due to the systemic and efficient work where each member of society will be responsible for their actions and will plan further life in Ukraine, creating comfortable conditions to implement their capabilities with the maximum interest in developing a democratic, transparent and innovative society and harmonious co-existence with the environment.

5. Conclusions.

When military operations end, Ukraine will face the problem of restoring territories, which will be complicated by the large number of destroyed facilities, ecosystems, and human and financial resources. Therefore, one should already develop scenarios of Ukraine's restoration based on innovative technologies and principles of improving the function of social welfare. One of the problems existing even before the war in Ukraine is waste management, which has caused degradation of the natural environment and environmental and economic damage, while European countries have already been establishing a green economic system and rationalizing environmental management.

One has found out that the best option of post-war waste disposal is the construction of mobile waste recycling complexes based on fractional waste recycling and its secondary use in further reconstruction of Ukrainian infrastructure, which after final restoration will be moved to safe areas around large cities and used as stationary waste recycling plants. To construct complexes with a minimum cost of 27.4 million USD, it is desirable to attract foreign partners and grants from government agencies of other countries, which will significantly reduce the burden on the state budget and increase the efficiency of project implementation.

To improve the environmental situation, one suggests building landscaped parks that will operate due to state-of-the-art technologies (obtaining natural energy, etc.) and creating a system of harmonious combination of anthropogenic infrastructure and natural areas, businesses, and public accessibility.

When calculating the cost of the restoration of Ukrainian territories, one should take into account additional expenses caused by hostilities, which will be further considered as a stress factor having a cumulative negative impact and leading to disastrous consequences that can be estimated in monetary equivalent as the sum of the price of restoration of components of the ecological, economic, and social system under the effect of a set of factors resulting in negative changes and damages.

The key goal of the reconstruction of Ukrainian territories is to establish an innovative, sustainable and safe system of social existence where each member of society will be fully satisfied with their life quality, and Ukraine's rating in the global space will become a pattern for other developing countries by increasing the efficiency of actions and methods to build a new sustainable society based on the principles of rational environmental management and increasing responsibility for our actions.

REFERENCES

Aliexpress (2022). Metal recycling machine. https://www.aliexpress.com/w/wholesale-metal-recycling-machine.html

Andritz (2022). Recycling industries. https://www.andritz.com/products-en/recycling/recycling/machines

Ding, Z., Gong, W., Li, S., & Wu, Z. (2018). System dynamics versus agent-based modeling: A review of complexity simulation in construction waste management. Sustainability, 10(7), 2484. https://doi.org/10.3390/su10072484

Eurostat (2022). https://ec.europa.eu/

Forbesua (2022). https://forbes.ua/inside/rosiya-vipustila-po-ukraini-raket-na-75-mlrd-otsinka-forbes-29042022-5753

HAAS Recycling Systems (2022). https://haas-recycling.de/en/

Hanson, T. (2018). Biodiversity conservation and armed conflict: a warfare ecology perspective. Annals of the New York Academy of Sciences, 1429(1), 50-65.

Islam, R., Nazifa, T. H., Yuniarto, A., Uddin, A. S., Salmiati, S., & Shahid, S. (2019). An empirical study of construction and demolition waste generation and implication of recycling. Waste Management, 95, 10-21. https://doi.org/10.1016/j.wasman.2019.05.049

Lauritzen, E. K. (1998). Emergency construction waste management. Safety Science, 30(1-2), 45-53. https://doi.org/10.1016/S0925-7535(98)00032-0

Liu, J., Yi, Y., & Wang, X. (2020). Exploring factors influencing construction waste reduction: A structural equation modeling approach. Journal of Cleaner Production, 276, 123185. https://doi.org/10.1016/j.jclepro.2020.123185

Map of Destructions (2022). https://reukraine.shtab.net/

Ministry for Communities and Territories Development of Ukraine (2022). https://www.minregion.gov.ua/

Noaman, A. S., & Alsaffar, A. E. (2019). A suggestion of a procedural method for the management of post-war waste. Civil Engineering Journal, 5(10), 2143-51. http://dx.doi.org/10.28991/cej-2019-03091400

Official statistics of Latvia (2022). https://stat.gov.lv/en

Spišáková, M., Mésároš, P., & Mandičák, T. (2021). Construction waste audit in the framework of sustainable waste management in construction projects—Case study. Buildings, 11(2), 61. https://doi.org/10.3390/buildings11020061

State Statistics Service of Ukraine (2022). https://ukrstat.gov.ua/

Tambovceva, T., Urbane, V., & Ievins, J. (2020). Innovations in Construction Waste Management: Case of Latvia. Marketing and Management of Innovations, 3, 234–248. https://doi.org/10.21272/mmi.2020.3-17

Yuan, H. (2013). A SWOT analysis of successful construction waste management. Journal of cleaner production, 39, 1-8. https://doi.org/10.1016/j.jclepro.2012.08.016

Zbgroup (2022). Product lines. https://www.zbgroup.es/

Zoghi, M., & Kim, S. (2020). Dynamic modeling for life cycle cost analysis of BIM-based construction waste management. Sustainability, 12(6), 2483. https://doi.org/10.3390/su12062483