ZERO BUILD JOURNAL

Derleme

Unver ve ark. 03:02 (2025) 41-70

Ukrayna Bina Stokunun Sürdürülebilir Yeniden İnşası İçin Strateji Çerçevesi Geliştirilmesi: Literatür Taraması ve Öneri

Umit Unver[*1,3], Nika Trubina[2,3], Antonín Lupíšek[2,3], Petr Hajek[3], Jan Tywoniak[3]

[1]Yalova Üniversitesi, Türkiye
[2]UCEEB, Czech Republic
[3]Czech Technical University in Prague, Czech Republic
*Sorumlu Yazar: umit.unver@yalova.edu.tr

Öne Çıkanlar:

- Ukrayna için sürdürülebilir yeniden inşa strateji çerçevesi önerildi
- 4 boyutlu ve üniversal bir yeniden yapılanma stratejisi üretildi
- Yeniden yapılanma programının bölgesel olması ve farklı bina tipolojilerini kapsaması önerildi.
- Yeniden yapılanma derhal başlayıp, artan hızla kademeli olarak planlanmalıdır

Geliş Tarihi: 01.03.2025 Kabul Tarihi: 13.04.2025 Doi: 10.5281/zenodo.15211663

Amaç:
Bu çalışma, savaş sonrası Ukrayna'nın bina stokunun sürdürülebilir bir şekilde yeniden inşa edilebilmesi için, mevcut literatürü inceleyerek, uygulanabilir bir temel strateji çerçevesi önermeyi amaçlamaktadır. Yeniden yapılandırma konusunda bu güne kadar yayınlanan, bilimsel araştırmalardan ve aktardıkları tecrübelerden yararlanarak uygun bir stratejisi çerçevesi oluşturmaktır.

Yöntem:
Araştırma, Ukrayna'nın savaş sonrası yeniden inşasıyla ilgili olabilecek yayınlara odaklanmıştır. "Bilim ve mühendislik" dışındaki alanlardan elde edilen yayınlar hariç tutulmuş ve geri kalanlar incelenmiştir. Savaş sonrası Ukrayna'daki bina stokunun yeniden inşası için özel bir strateji çerçevesi tanımlanmak için, araştırma kapsamı diğer yıkım türlerini de kapsamak üzere, afet sonrası yeniden inşa stratejilerini de içerecek şekilde genişletilmiştir.

Sonuç:
Yeniden yapılanma için, eyleme hemen başlayıp kademeli olarak artan, hem ekonomik hem de teknik adımları dikkate alan, çok aşamalı bir program uygulanmalıdır. Program Ukrayna'nın her bölgesi için, bölgenin kendi koşullarına ve kaynaklarına göre hazırlanmalıdır. Ayrıca farklı bina tipolojilerini ayrıca kapsamalıdır. Bu çalışmada önerilen strateji, her türlü afette uygulanabilir niteliktedir.

Anahtar Kelimeler: Ukrayna'nın Yeniden Yapılanması, Savaş Sonrası Yeniden İnşa, Yeniden Yapılanma Stratejisi, Afet Sonrası Yeniden İnşa, İhya Planı, Lugano İlkeleri

ZERO BUILD JOURNAL

Review

Unver et al. 03:02 (2025) 41-71

Developing Strategy Framework for the Sustainable Reconstruction of the Ukrainian Building Stock: A Literature Review and Proposal

Umit Unver[*1,3], Nika Trubina[2,3], Antonín Lupíšek[2,3], Petr Hajek[3], Jan Tywoniak[3]

[1]Yalova University, Türkiye
[2]UCEEB, Czech Republic
[3]Czech Technical University in Prague, Czech Republic
*Corresponding Author: umit.unver@yalova.edu.tr

Highlights

- A sustainable reconstruction strategy for Ukraine is proposed.
- A four-dimensional and universal reconstruction strategy was developed.
- The reconstruction program is recommended to be regional and to encompass different building typologies.
- Reconstruction should be planned to commence immediately and intervene with increasing speed.

Received: 01.03.2025 Accepted: 13.04.2025 Doi: 10.5281/zenodo.15211663

Abstract: The term "reconstruction" in this paper refers to the process of rebuilding an object that has been damaged or destroyed, essentially following disasters, in this case unfortunately man-made. This paper highlights the impact of the war in Ukraine on various sectors, including agriculture, energy, education, the environment, and especially the building sector. The objective of the study is to propose a viable basic strategy frame for achieving sustainable reconstruction in Ukraine by reviewing existing literature. The research primarily concentrates on the post-war reconstruction of Ukraine. From the results, papers except from "science and engineering" area were excluded and the rest was reviewed. Despite an extensive literature on post-war reconstruction of various sectors, there was not yet described a specific strategy for reconstruction efforts for building stock in Ukraine. Therefore, the scope of the investigation was expanded to include studies on reconstruction strategies following after disasters. This study introduces a general, sustainable and basic strategy for reconstruction. The proposed strategy considers Gradual, Regional, and Typological dimensions. The outlined strategy can be implemented in the aftermath of diverse catastrophic events, ranging from natural disasters to war-torn cities.

Keywords: Reconstruction of Ukraine, Postwar Reconstruction, Reconstruction of Building Stock, Reconstruction strategy, Post-disaster construction, Revival plan, Lugano principles

CONTENT

1. Introduction

Reconstruction literally means "the process of building or creating something again that has been damaged or destroyed". But the meaning of "something" in this definition and in the context of the Russian invasion of Ukraine is very broad. It covers many areas from agriculture - to energy, from economy - to tourism. In this paper, a literature review will be presented for the Sustainable Reconstruction of Ukraine (SRU). The main aim of the research is to propose an appropriate reconstruction strategy for sustainable reconstruction of the building stock in Ukraine by investigating through the recovery and reconstruction studies.

1.1. Broad effect of the war

In February 2022, the world was shocked by the Russian invasion of Ukraine. War has affected all areas of people's lives and government activities [1]. Deep impact is seen in a wide range of sectors, including agriculture, tourism, the economy, energy, and others. In addition to Ukraine, the harm also impacts the rest of the world, most notably Europe [2]. Scientists are examining the damage and potential solutions to help various sectors get back to normal, or in the ideal case, to improve them to a higher level than they were before the war.

The devastating effect of the war on Ukraine has had a significant impact on the business sector. In the first three months, companies almost halved their activities, although later the retail, white goods, electronics, and jewelry sectors showed signs of recovery. However, the entertainment industry experienced the worst recovery rate. Unfortunately, the interruption of the supply chain, decrease in purchasing power, demand changes, and uncertainty negatively impacted the business world [3]. Agriculture is a crucial industry for Ukraine, one of the world's largest exporters of wheat and fertilizers. The war has had a negative impact on the production of agriculture, most notably food products, consequently making food security a concern for many countries worldwide [4]. The food and agriculture hold great significance in Ukraine's 2030 Sustainable Development (SD) plans. The achievement of other Sustainable Development Goals (SDG) is reliant on reaching SDG2: end hunger [5].

Another important research area is the energy security [6]. The Ukrainian and European energy markets, which were directly and indirectly dependent on Russia due to their dependence on natural gas, are extremely sensitive. The Russia-Ukraine war reveals the need to refocus on geopolitical energy security in Europe and around the world. Countries are trying to transform sustainable and green transition formulation on energy into policy in a shorter time [7].

It is stated that, as Russia during war times, supplied the most of Europe's energy, Europe will continue to face the risks of disruption to its energy supply [8]. In this case, the war acts as a catalyst that accelerates the greening of Europe. The War naturally affects public policy support for policies aimed at phasing out fossil fuels and promoting the introduction of clean energy alternatives. In Switzerland, for example, support for policies to reduce fossil fuels has increased drastically because of the war. Before the war, there was an opinion that Ukraine should develop environmental policies that prioritize climate change. Highlighting the accountability of executive and local government bodies, it was recommended to ensure accountability of executive and local government bodies and a transformational transition to renewable and sustainable development technologies.[9].

The war also affected the education sector. As of 24th February, 2023, a total of 2,772 education institutions were impacted by the war, with 454 buildings destroyed in total nearly 10 percent [10]. Depriving children of education is not an option, which is why educators feel obliged to continue uninterrupted teaching and provide psychological guidance and counseling to their students [11]. These efforts of Ukrainian educators should be supported and the potential of education sector should be enhanced after the war for sustainable recovery and development. In this respect, the priority activity of the Ukrainian state is to develop the education standards in accordance with the best educational practices in Europe [12]. Starting in 2019, the Ministry of Education and Science of Ukraine has successfully attempted to implement educational reform. The key one is the concept of the New Ukrainian School. This concept covers changes in the educational process itself, and it proposes an effective approach to develop “New Educational Space” by retrofitting buildings to enhance energy efficiency, providing barrier-free space and conditions for inclusive education, creating a motivational space, and using modern equipment.

1.2. The Studies on the Sustainable Reconstruction of Ukraine

The focus of this paper is defining a suitable strategy for post-war reconstruction of Ukraine building stock. To summarize the related scientific studies so far, we have reviewed the literature. We used Web of Science (WoS), Scopus and Google Scholar database using the keywords “Ukraine” and “sustainability” and “reconstruction”. Excluded the subject areas: physics, heal, immunology, medicine, nursery, pharmacology, and arts. The publication date was limited to 2022 and 2023 since we were dealing with invasion of Ukraine. In Google Scholar research, the exact phrase of “sustainable reconstruction” was searched since otherwise Google brought more than 66000 results.

Table 1. The papers reviewed on the Sustainable Reconstruction of Ukraine

No	Reference (Source)	Keywords of the papers
1	[13]***	Open innovation, tourism, tourism friendly cities;
2	[14]**	Tourism,
3	[15]*	Rural tourism; environment; Sustainable development
4	[16]*	Agritourism, rural areas, rural green tourism, Sustainable development
5	[17]*	Thermal Engineering
6	[18]**	Heating, Thermal Engineering
7	[19]***	Energy Communities, renewable energy, energy transition
8	[20]**	Renewable Energy, Financing
9	[21]**	Energy and Fuel
10	[2]**	Energy policy, energy security, diversification
11	[6]**	Energy policy, energy security
12	[22]*	Energy and fuel, energy security
13	[8]*	Energy, business, energy market
14	[7]*	Energy security, Sustainable energy transitions
15	[23]*	Renewables, presumption, households
16	[24]*	Renewable energy, circular economy
17	[25]*	Energy, renewable energy, agricultural biogas, economic feasibility
18	[26]*	Climate policy, Public opinion, Renewable energy, Sustainable finance
19	[27]***	Climate change, climate action
20	[28]**	Climate Change, bioclimatic potential
21	[4]*	Circular economy, climate crisis, green industrialization
22	[29]***	Sustainable Development Goals
23	[30]**	Sustainable Development Goals
24	[31]*,**,***	Sustainable Development
25	[32]**	Sustainable Development, Urban Architecture, Medical Centers
26	[33]**	Sustainable development, territorial development, economy
27	[34]**	Decarbonisation, green transition, sustainable development
28	[35]**	Urbanization, sustainable development, environmental policy,
29	[36]**	Urbicide city, urbanization
30	[37]*	City revitalization, industrialization, sustainable development,
31	[38]**	Contemporary Architecture, Philosophy in Architecture, Urban Context
32	[39]*	Sustainable development, regional economy, decentralization.
33	[11]*	Education, sustainable development, professional integrity
34	[40]*	Higher education, funding, sustainable and human development
35	[41]*	Sustainable Development, Financial performance, Financial Resiliency
36	[42]*	Economy, sustainable development
37	[43]*	Sustainable development, public-private partnership, intern. partnership
38	[44]***	Recovery and Reconstruction of Ukraine
39	[45]***	Recovery and Reconstruction of Ukraine
40	[46]***	Recovery and Reconstruction of Ukraine
41	[47]**	Resilience, War-torn, Critical infrastructure, Recovery, Prioritization
42	[48]**	Construction and repair works, road

Table 1. The papers reviewed on the Sustainable Reconstruction of Ukraine (Continued)

No	Reference (Source)	Keywords of the papers
43	[49]**	Logistics, Ukraine
44	[50]*	Smart buildings, reconstruction
45	[12]*	Recovery of education
46	[51]**	Economic recovery, Innovation, Digitalization
47	[52]**	Economic recovery, economy
48	[53]*	Housing, construction market
49	[3]*	Marketing, business, retail, sustainability, economy,
50	[54]*	Housing stock, Repair, Privatization, Tenants, Subsidies
51	[55]*	Sustainable development, small business, economic growth
52	[56]**	Anthropogenic landscapes
53	[57]**	Soil, ecology, agriculture
54	[58]**	Environment, heavy metals, agricultural lands,
55	[59]**	Ecosystem, soil, urban park
56	[60]*	Urban green areas, landscape and recreational zones
57	[61]**	Recycling, Postwar recycling, concrete
58	[62]**	Construction waste recycling
59	[9]*	Environmental policy
60	[63]*	Waste management, sustainable development
61	[64]*	Waste recycling, energy and fuel
62	[65]**	Digitalization of the agricultural land
63	[66]**	Digitalization, food sector, circular economy
64	[67]**	Digitalization, food security, agriculture
65	[5]*	Food Security, sustainable development
66	[68]*	Food security,
67	[69]*	Agriculture, forestry
68	[70]*	Agriculture, climate change actions
69	[71]*	Agricultural sector, agricultural enterprises
70	[72]**	Spatial organization, system development,
71	[73]**	Revitalization of the industry
72	[74]**	Nighttime lighting vs refugee number.
73	[75]*	Law
74	[76]*	Flooding, Ethnic disparity

* Web of Science, ** Scopus, *** Google Scholar

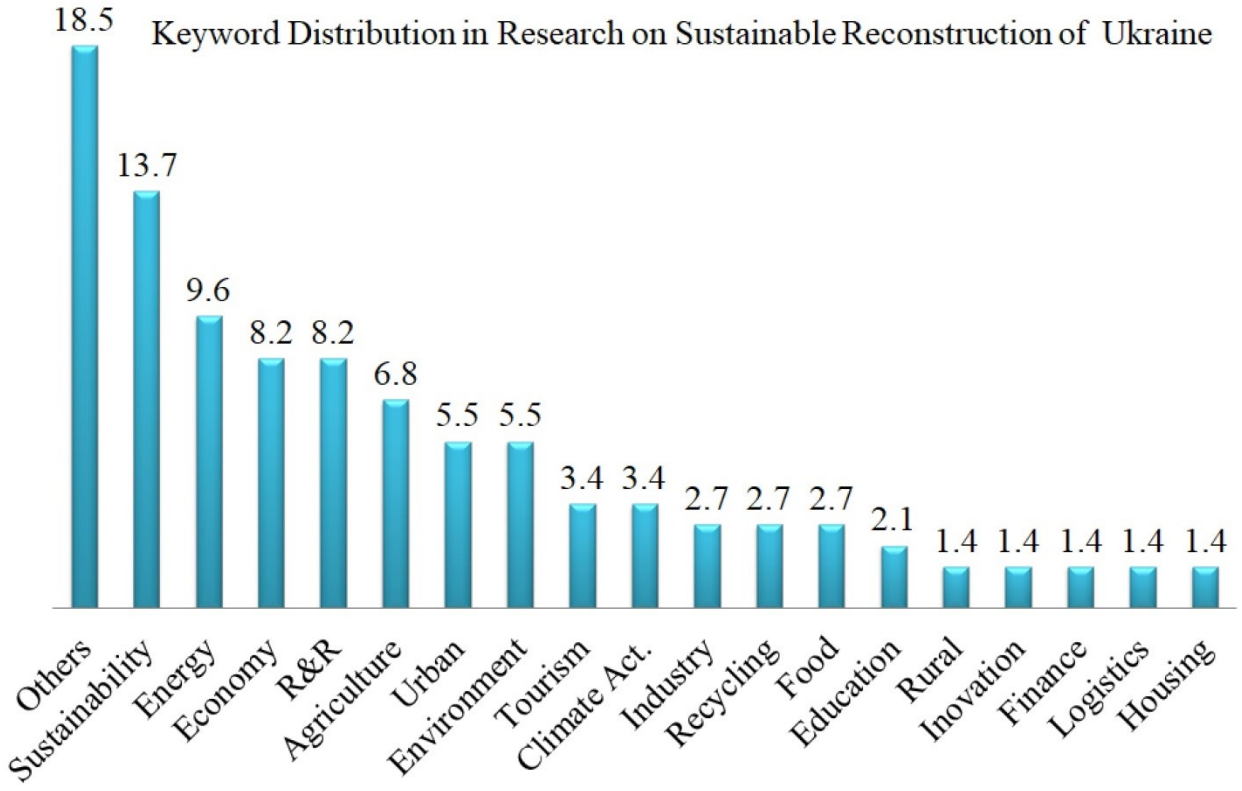

Figure 1. The keywords of the literature reviewed within the research on "Sustainable Reconstruction of Ukraine"

Then we have eliminated the papers which were not related with Russian invasion of Ukraine. Uniting the results and removing the duplicated studies, Table 1 was designed.

Then we grouped the keywords and Figure 1 illustrates the distribution of the keywords. The numbers over the bars show the percentage of the keyword in overall total of all keywords. In Figure 1, the 'Others' column includes keywords that appear only once, such as presumption, public opinion, bioclimatic potential, medical centers, territorial development, architecture, decentralization, professional integrity, human development, partnership, prioritization, smart buildings, housing, subsidies, law, etc. Keywords that appear two or more times are included in Figure 1.

In searches for 'Sustainable Reconstruction of Ukraine,' the most frequent keywords—sustainability (14%), energy (10%), and Recovery and Reconstruction (R&R) (8%)—highlight the crucial link between sustainable reconstruction and energy efficiency. Additional keywords like urban (6%), environment (6%), climate action (3%), and housing (1%) emphasize the need for a holistic approach to rebuilding that considers broader environmental and urban contexts.

The invasion seriously affected Ukraine. Scientists examine each sector separately and offer methods for restructuring the sector. We used the Litmap tool to correlate the articles we encountered during the literature review, to see the relationship between the papers. None of them has a citation link with the other. This is because firstly; the papers were

published in the same year after the invasion started on February 2022 and secondly; each study describes an individual content. Moreover, the peer-reviewed literature published with “Ukraine + reconstruction + sustainability” keywords do not help determine a post-war reconstruction strategy. The keywords of the recent studies were not exactly cover sustainable reconstruction but covered similar concepts namely; sustainable development goals, food security, energy security etc. (Fig. 1). However, through 74 relevant scientific papers we investigate, none of the existing studies propose a “reconstruction strategy” for the building stock.

To address this gap, our research focuses on the “Sustainable Reconstruction of Ukrainian Building Stock,” highlighting and encapsulating sustainability, energy, and urban development to tackle the complex challenges of Ukraine's reconstruction.

In this paper, a detailed literature review has been performed on the reconstruction of Ukraine since the beginning of the invasion. Since the publications on Ukraine's sustainable reconstruction are insufficient, the content of the paper has been expanded with the title of “post-disaster reconstruction”. Thus, a basic framework reconstruction strategy was created and introduced. The main contribution of this paper is, providing a universal reconstruction strategy, which can be employed in case of any kind of disasters considering regional development, sustainability and stepwise reconstruction.

2. Reconstruction; Definition and Ukrainian Implementation

2.1. Reconstruction: Evaluation of challenges and recommendations

This paper focuses on drafting the basic principles for the post-war sustainable reconstruction of Ukrainian building stock. Therefore, we will first seek an answer to the question "What is reconstruction, and how is it defined?" before moving on to the question "How exactly can a good sustainable reconstruction strategy be determined?"

Today, due to climate change and other natural causes, we are faced with natural events such as fire, earthquake, flood and overflow more frequently. If necessary precautions are not taken against such natural events beforehand, these events turn into disasters. A disaster can also be anthropogenic, such as war. Whatever the source of the disaster, man-made reconstruction is essential.

If disasters were predictable, it would be much easier to avoid loss and take precautions. However, the reality is unfortunately not like this, and the consequences of disasters can be extremely catastrophic. Some principles and approaches can be used to meet the needs such as food, hygiene and shelter in a planned and programmed manner as soon as possible so that people affected by disasters can survive and hold on to life [77].

Disasters can destroy lives or cities with an impact that lasts for years in a few seconds. This can lead to the destruction of not only human life, but also the economic life. Therefore, restructuring and saving economic enterprises in such disasters are one of the key

tasks for the recovery of social life as soon as possible [78].

While cities are being built, each building is designed individually for separate purposes. However, reconstruction after a disaster takes a much shorter time than new construction, and is characterized by inherent complexity and chaos due to its large scale and the need for simultaneous reconstruction of various structures. In such cases, in order not to be insoluble, to save the lives of the most number of people as soon as possible, to fulfill the social life and needs as soon as possible, it is absolutely necessary to prepare in advance, design applicable programs and develop disaster policies [79].

Construction activities in the recovery process are comparatively more intensive and sophisticated than normal construction by nature. After a disaster, many institutions and charities are involved in the reconstruction process. In order for this sometimes chaotic process to be successful, it must be well planned with a multidisciplinary professional team and appropriately designed programs [80]. Government, disaster victims and Non-Governmental Organizations (NGOs) are the main actors in a recovery project and share the responsibilities of program initiation, project initiation, project financing, design, reconstruction, post-project changes. For an unbiased process, it would be helpful to integrate international scientific organizations into the reconstruction plan, so Ukraine's scientific knowledge could be improved with the support of international stakeholders [52]. Beforehand, the factors that will affect success and the success criteria should be determined and the process should be designed accordingly [81]. The most important success factors for post-disaster reconstruction are defined as: Effective organizational regulations, professional management and professional teams, coordination and cooperation, supportive legislation, fast and effective information and communication management key partners clearly defined success criteria, logistics, resource utilization [82]. However, it is important to have an overview of possible major issues or problems for the reconstruction process: financing, relocation, land ownership, construction material, construction cost, construction labor, construction quality, local capacity, charity capacities, coordination, communication, political environment. Without an appropriate disaster management policy, these issues can grow and become unsolvable problems [82]. On the other hand, It has been emphasized that strong leadership and social cohesion are important for disaster preparedness, disaster response, and post-disaster reconstruction [83]. If public institutions and NGOs do not prepare professionally and scientifically for such disasters, the only effect of such a structure is to slow down the vitally important emergency response and enlarge the problem.

The resource that can be used for recovery are listed as: natural resources, cultural resources, human resources, social resources, political resources, financial resources, and structural resources that can support other resources. The reactions of different societies to disasters and the use of resources may be different. The resource planned in disaster preparedness may affect the ability to use resource of all subsequent phases [83]. Unplanned resources may prevent utilization of the other resources. From this point of view, each society needs to prepare differently for each disaster, and it is

necessary to plan each of the above-mentioned resources as capital in a multidimensional manner.

Finding appropriate financial resources at the right time in coordination with local governments, identifying users, determining the appropriate assistance method, participation of enough and various stakeholders in the reconstruction, risk and time management are defined as key parameters of the planning stage. During the design phase, selection of suitable sites, problem-free land use, physical plan, quality definitions, determination of suitable construction types, sustainability, reduction of future disaster risks, design according to building typologies, program, resource planning and risk management should be considered. Also, different application methods, management of construction projects, characteristics of materials, procurement and transportation, labor and labor management, delivery, maintenance and after-use evaluation of completed projects, should be considered. The construction phase is not just about returning people affected by the disaster to their normal lives. At the same time, it is a process that provides an opportunity to prepare for the next disaster and reduce the impact of the next disaster with all kinds of measures to be taken [84].

While planning the recovery, the situation of reconstructing in a wider area, scenarios that can solve the "geographical inertia" problem that means the constant occupation of dangerous places, the approaches that will protect the "spirit of the place", sustainable disaster reduction, producing vision, defining the efficiency of reconstruction and increasing its impact should be studied [85]. Recovery opens many windows of opportunities. In the restructuring of the city, if necessary, stylish investment projects should be put on hold and the spirit of the city should be preserved after the urbicide [36].

Advanced and versatile planning is the key factor for disaster recovery that should also cover economic losses. Contrary to physical losses, economic losses continue cumulatively until the end of the recovery process. If these losses are not compensated appropriately and quickly, they may result in the emigration of the citizens [86]. This means that the demographic structure changes affects not only in the location affected by the war or disaster, but also other countries starting from nearby places. As developed countries like Europe or USA attract more attention, they will be the address for resettlement. Similar effects are observed both in the Ukraine war and in Syria. For example, when the Syrian civil war started in 2011, as a first reaction, around 30% of people fleeing the war preferred to seek refuge in 28 EU countries [87].

2.2. Challenges is reconstruction studies performed so far for other disasters

Disasters of all kinds, whether anthropogenic or natural, are projected to increase greatly in the frequency and magnitude of events. The population affected by the increasing disasters in recent years is forced to leave their homes. For example, approximately 17.2 million people were left homeless in 2018, with US$250 billion lost in damages, leaving approximately 26 million people in poverty over the world. Mass deaths also occurred during and after disasters [77]. The International Disaster Database states that between 2000 and 2019, a total of 1.65 billion people worldwide were affected by the floods,

causing a total damage of 563 billion USD. Institutions such as the World Bank recommend the use of assessment tools such as Social Impact Assessment tools in the context of "understanding disaster risk" in order to detect disaster effects in a shorter time and better [88]. The Planning for Post-Disaster Recovery and Reconstruction handbook provides policies, the planning process, and more to guide planning for post-disaster recovery and reconstruction [89].

In order to achieve a sustainable recovery, the risks must be known and appropriate structuring must be selected. "Geographical inertia" must be resolved by legislation. If possible, reconstruction plans should be made before the disaster, separately for each disaster type [85]. For example, choosing lightweight structures for a hurricane is not an appropriate selection. The height of the structures planned for the earthquake should be determined according to the frequency of the seismic vibration produced by the region's ground. In post-war reconstruction, the layout of the city should be in such a way to make a military intervention difficult and to facilitate defense.

The "window of opportunity" perspective is the assumption that there is greater potential for resolving social problems after a disaster than before a disaster. Many people hope, after a disaster, that the disaster will accelerate their hopes and plans for change and development. Disasters can revitalize a society, and even restructuring efforts can make society a force for improvement and upgrading [90]. On the other hand, there is no guarantee for this process to be successful and the failure of the process can be due to lack of resources, lack of government support, budget limitations, delay in the process, and lack of community contribution [79].

It is stated that one of the most important topics for post-disaster recovery is logistics [91]. Because, if the roads are damaged in a disaster, losses and damages increase at every stage of the disaster recovery that brings extra burden to the society. In the case of the war in Ukraine and the earthquake that occurred in Turkey, it was observed that not only the damage to roads but also the damage to air, railway and sea transportation increased the losses exponentially.

2.3. Recovery studies performed on Ukraine so far

2.3.1. How to Recover?

Disaster management has three stages and starts before the disaster. The steps are described as: mitigation and preparedness before the disaster, response and post-disaster recovery [44]. Post-Disaster Recovery, on the other hand, is described as a four-stage process. Emergency response, restoration, reconstruction and upgrade [79]. Disaster management and post-disaster reconstruction management can be evaluated together starting from the "Emergency response". In order for the process to be carried out successfully, it is important to have transparency, accountability, clearly defined goals, providing education and guidance to the community, good coordination and cooperation, evaluation and performance measurement [81]. This study provides an example for mitigation and preparedness before the disaster step.

The aim of the reconstruction of all kinds of disasters is to meet human needs and to normalize social life. Therefore, the recovery action begins as soon as the disaster begins

with the "emergency response" stage until the social life is enhanced to a better state than before. In this process, all disciplines of management i.e. logistics, information, quality, risk and project must be managed simultaneously and jointly. Therefore, recovery can be defined as an interdisciplinary and cross-sectoral process, meaning that it requires stakeholders from many sectors to come together.

Recovery can be performed much more effectively and accurately with today's technology and decision making techniques. However, no matter how advanced technology is used, an appropriate strategy must be determined, appropriate data must be processed and continuous damage/due diligence assessments must be carried out. Damage/due diligence assessment should take into account the identification of needs, assessment of critical infrastructure, assessment of available resources, and recurrence of damage due to war [47].

For Ukraine's future practice, it is necessary to take into account that the post-disaster recovery process frequently fails due to a lack of finance, insufficient support from the government, lack of funding and supporters, and a lack of community involvement [79]. It should be noted that, the quality of humanitarian aid operations is defined by parameters such as supportive policies, transparent and quality information sharing, response rate and security measures. In addition, there is a gap in the disaster management system in terms of proactive identification of victims, design of strategic programs, flow of funds through innovative platforms to provide adequate assistance to victims [77]. If additional factors like inadequate integration, inappropriate evaluators, corruption, poor communication and coordination, ineffective/wrong planning, and logistics are taken into account, the reconstruction process will unavoidably fail [81]. A simple and convenient way to success can be considered as international cooperation with financial, academic and professional institutions. As an academic institution, our target is to develop an appropriate strategy for reconstruction.

2.3.2. Ukraine Situation and Losses

The invasion killed thousands and started an influx of refugees. By June 2022, about 8 million Ukrainians were internally displaced and by February 2023, other more than 8 million Ukrainians had left the country. It is predicted that about US$80 billion in government funds will be needed for short-term needs within the framework of restructuring for profits-generating industries that are expected to recover and restore crucial public sector assets, such as schools and roads, and speed recovery [74, 92].

As of June 1, 2022, the total damage only in the housing sector is estimated to be USD 39.2 billion. About 817,000 settlements were affected by the war, and 38 percent of them were destroyed beyond repair. The war had significant effects on the urban housing stock [92]. Ukraine's housing stock ages early as a result of a lack of maintenance funding resources. A portion of the pre-war population resided in these inferior technologically constructed homes [50]. The real estate sector was negatively impacted by the political instability and the war has heightened the drama of this scenario. The real estate market is anticipated to contribute greatly to the reconstruction process. It is recommended that land, air, and sea transportation be

perfected in order to boost the region's worth and revitalize the real estate market [53].

2.3.3. Energy Stress

Ukraine is energy – dependent country. This dependency threatens both some sectors such as manufacturing and logistics and national security in the country. Its main energy source is natural gas, which is Russian origin. Ukraine consumes 40% of the total energy in the buildings [93]. Similarly, European Union is sensitive in energy issues. EU publishes energy efficiency legislations in buildings, green transition, smart and sustainable growth, and institutional resilience policies. With the "Smart Energy Saving" project developed in this context, it is aimed to reduce the negative effects on energy saving, sustainability and the environment with the subsidy programs supported by the European Union funds [94]. The European Union defines energy efficiency studies as a valuable tool to overcome energy supply challenges. The aim of energy efficiency studies is to contribute to supply security by reducing primary energy consumption and energy imports. Today, Ukraine needs to reduce its dependence on energy both because of the use of energy supply as a weapon against itself and because of its responsibility to fight the climate crisis [93]. The simplest method that countries can implement and develop policies to reduce their energy intensity is the energy efficiency in buildings. With the energy efficiency studies in the buildings, both the economy is contributed in the production phase and massive overconsumption is prevented during the operation phase. Therefore, energy stress leads post-war reconstruction strategies of Ukraine towards energy efficient buildings.

2.3.4. European Integration

The National Council for the Recovery of Ukraine from the Consequences of the War (NCRU) has stated willingness for interregional and cross-border cooperation in the plan “Construction, urban planning, modernization of cities and regions”. The plan also states that international partners are expected to be involved in the recover and improvement process. The war accelerated Ukraine's EU membership and gave a "candidate" status. Therefore, it is expected that European principles, approaches and practices will be further supported in the improvement process [93].

NCRU's “Energy security” plan also envisages financing various projects using the European Green Deal Investment Plan (Invest EU or Just Transition Fund). Significant funds are planned to be allocated, particularly for the implementation of Pilot technologies involving green energy [95]. However, while it is possible for Ukraine to temporarily apply foreign standards, local standards must eventually be amended to align with the EU acquis [92]. In “Construction, urban planning, modernization of cities and regions” plan, NCRU states that the system is not technically ready for EU conformity assessment in the field of construction [93].

NCRU also stated that an inclusive modernization plan integrated with the EU was made in the process of saving economic and social life and improving natural ecosystems. The plan aims for accelerated, sustainable economic growth to ensure people's well-being integrated into European value chains [95]. In the “European Integration” Plan, it is stated that the employment of professionals with the sectoral

competence required for EU integration will contribute to the acceleration of the harmonization process [96]. The project "Development of the Interagency Program on Environmental Education and Awareness Raising for Sustainable Development of Ukraine for the Period 2022-2032" was launched for each region of Ukraine. In the project, plans and standards were developed on infrastructure, health services, housing and schools, and digital and energy sustainability in line with European policies. It is planned to increase the quality and effectiveness of environmental education so that the citizens receive sufficient and up-to-date environmental information [96]. In the plan it was stated that Ukraine will be rebuilt in a clean and safe way, ensuring compliance with the Copenhagen criteria for European Union (EU) integration and EU Green Deal [93]. Similarly, the World Bank recommends that the reconstruction process be planned in a way that integrates sustainable development and green transition in line with the 2030 goals and the Paris Agreement [92].

All of the published plans state that the recovery should proceed in parallel with the EU Integration process. At the same time, all plans require technical expert personnel, training support and expert support from international stakeholders. The EU reports that, upon request, Member States will be assisted in establishing national or regional financial support schemes to improve energy efficiency in buildings [97] either directly or through European financial institutions [98].

In the recovery of Ukraine project, an institution namely, “Institute for Sustainable Reconstruction of Ukraine” to provide technical support can be suggested. This Institute will also contribute to the implementation of the principles of partnership, reform focus, transparency, democratic participation, multi-stakeholder participation, inclusiveness stated in the Lugano Declaration. The institute may contribute to the specified issues in the “Construction, urban planning, modernization of cities and regions” Plan, by following actions:

- Build and develop the capacities of authorities and institutions at all levels and ensure cooperation for post-war reconstruction and development.
- Establish a system for regional development institutions,
- Establish a data-based policy and decision mechanism,
- Provide methodological and informational support for the development of local self-government,
- Establishment of education and training programs for the employees of regional development agencies [93].

The EU foresees that the highest improvement can be provided with the easiest intervention in strive against the climate crisis in the housing sector. For this, it has targeted by defining Zero Energy Buildings in Directive 2010/31/EU on the energy performance of buildings that requires member states to provide, on their own terms, appropriate financing and facilitation to promote energy efficiency in buildings and accelerate the transition to zero energy buildings [97].

In Directive 2018/844, the Council announced that Member States should develop long-term renewal strategies to promote skills development and training in the construction and energy efficiency sectors. Accordingly, Member States should establish a long-term strategy for the renewal of the national building stock. These strategies are desired to

contain: building stock assessment, determination of renovation approaches related to building type and climate zone, policies to encourage renovations and a forward-looking perspective [98]. Ukraine's improvement project can be staggered until 2050 in parallel with this directive. Accordingly, zero energy buildings are targeted and plans are made considering the building type and climate zone, which is in line with the Ukraine recovery plan [93].

The 2012 directive recommends that member states encourage information on progress made in achieving the targets [99]. The recommendation given here is also consistent with transparency, which is the cause of failure of restructuring projects by [81]. In line with EU jurisprudence, the same work plan can be used for Municipalities of Ukraine. In view of the shortage of experts reported by the NCRU, it may be appropriate to appoint a third-party institute to provide support for specialist staff training and transparent reporting.

40% of energy consumption in Ukraine takes place in buildings. As more than 80% of the buildings were built before 1991, they do not meet modern energy efficiency requirements. The average specific energy consumption in buildings is about 194 kWh/m2. This is 30-50% above the European average. A large part of the heat in buildings is lost due to poor thermal insulation, aging of the installations, wear and inefficiency of use. By implementing the zero energy buildings target to reconstruction strategies,, a 35% increase in energy efficiency in the building sector is targeted with Net Zero Energy Buildings (NZEB) in the medium-term plan [93].

3. Discussion of The Guiding Principles for Ukraine's Post-War Reconstruction

So far, recovery management, successful planning, factors that can cause failure, Ukraine's NCRU reports and the government's plan, relevant sections in EU legislation have been examined and a general view has been presented. In this section, we will outline the principles of recovery from the general information gathered.

Before the war, the Ukraine published a program and environmental policy on ecological networking, biodiversity conservation, waste management and use. However, political and administrative uncertainties, lack of implementation strategies, and finally Russian aggression hindered the implementation of these programs [9]. From now on, without waiting for the end of the war, reconstruction for a sustainable Ukraine with a renewed strategic roadmap should be started.

Recovery can be defined as change and transformation for the normalization of basic service and social infrastructure [81]. The reconstruction process consists of 4 stages:

i. urgent action,
ii. provision of essential services,
iii. relocation and reconstruction,
iv. developmental reconstruction.

This process can take up to 25 years, depending on the magnitude of the disaster and the affected community [85]. Therefore, a medium-term plan should be made for the rapid restoration of basic infrastructure and services in the process, followed by laying the foundations for sustainable and green growth [39]. However, this plan should be updated with data from the field and continuously

improved if necessary. The “policies to be followed” recommended in the studies on the reconstruction of Ukraine can be grouped under 2 main headings: Technical inferences, and administrative inferences.

ADMINISTRATIVE INFERENCES: The reconstruction process is considered by many researchers as an "opportunity to build better". However, if the long-term sustainability of the region's economy is not taken into account, it can lead to a "boom and bust" economy [85]. Therefore, it should be planned very carefully and consciously. Because it's not just the work of rebuilding buildings, it's the process of rebuilding the society. If appropriate techniques are not used, significant problems such as individual inequality, inequality of access to resources, inequality of opportunity and a society vulnerable to disasters can arise.

In the reconstruction process, the regions with the highest economic and political relations with the other countries are the places that the most easily and quickly recovered after the disaster [100]. Therefore, International Public-Private Partnerships (PPP), aimed at strengthening foreign relations, is very important for the restructuring of Ukraine. The establishment of international PPP depends heavily on public support [43]. If the PPP is established with stakeholders like European Union, World Bank, European Bank for Reconstruction and Development (EBRD), it becomes an extremely attractive tool for attracting investment in the reconstruction of social and economic infrastructure.

However, foreign aid programs must be managed in a flexible and transparent way. Administrative and political interventions are among the greatest dangers and obstacles to a successful recovery. If the professional experts' plan is replaced by other personal or political interests, the benefit of some small groups may increase, but the overall benefit of the country will decrease and sustainability will be severely damaged [101]. Furthermore, it is recommended that priority be given to developing cooperation for the effective use of resources and, where possible, providing external assistance in the form of grants [102]. Ukraine should implement changes related to integration with the EU, seriously challenge corruption while receiving support, and establish the framework for restructuring. If the restructuring process is designed to include all stakeholders in accordance with the project management cycle technique, equality, transparency, performing a better and sustainable reconstruction can be achieved [82].

Inference 1: A special-purpose, multi-partner institution can be appointed to avoid the negative effects of domestic politics, facilitate international cooperation, and streamline the project management cycle. This private institution, with global stakeholders as partners, manages and reports on the reconstruction process as a third party. It can provide the speed, transparency, and versatile information flow necessary for the healing process.

World Bank recommends to allow private sector investments and initiatives and to develop support programs for Small and Medium Enterprises (SMEs) for the recovery process. Thus, the building back better process of damaged properties can begin immediately and be increased gradually. This method is also recommended as a suitable

method for the equitable distribution of welfare [92].

Inference 2: Starting the action immediately and increasing gradually can be possible with a stepwise program. Both economically and technically steps should be considered. With a gradual planning, better and more sustainable targets can be set. The process can be started to the extent available resources allow.

Social conflicts can slow or halt even the best-planned reconstruction and recovery efforts. If Development Conflict Resolution Techniques are used to prevent such a situation, conflicts can be prevented and sustainable recovery can be achieved. For this, social resources, social networks and social participation can be developed to increase the "capacity of the community" to solve problems and increase well-being during recovery. By this way, an important contribution can be made to build environment for resilience against future disasters [103]. In the draft plan “Reconstruction, urbanism, modernization of cities and regions” published by the NCRU, a sustainable reconstruction should be planned according to the needs of society. Priorities should be determined and ranked, and a project should be prepared by determining technical and commercial strategies. In order to give priority to regional development, national SMEs should be enlarged and the number of companies should be increased and contribution to the economy should be ensured. A modern human-centered approach in line with sustainable development goals should be adopted. Restructuring efforts should be planned to contribute to Ukraine's integration into the European Union [93].

TECHNICAL INFERENCES: Today, there is a chance to integrate Ukraine into the global economy with investments by prioritizing increasing production capacity and transition to the high and green technology [102]. In addition, energy efficiency, smart public transport and climate resilience in urban areas should be prioritized in the rebuilding process. Energy infrastructure should be specially planned and a strategy on agriculture and regional development should be planned [45].

Inspiring by the Marshall plan, the recovery plan should be [46];

i. Organized to promote economic independence,
ii. Administered by Ukraine,
iii. Revised based on ongoing needs assessments
iv. Giving priority to resource conservation and sustainable development.

Inference 3: The strategic plan should be prepared in accordance with the regional development. Thus, the reconstruction will be shaped according to the needs of the region to ensure that it contributes to the economy of that region. Making a special reconstruction plan for each region will shorten the reconstruction period and increase its effect.

In the light of the drawn remarks so far, it was concluded that international organizations should also contribute to the reconstruction process, that the program should be started immediately and accelerated gradually, and that a separate plan should be made for each region. So what should be the upper limit of the plan? To what extent should the plan envisage improving Ukraine's existing building stock? The answers to these questions are actually parallel with the EU integration topic. In the “European

Integration" Draft Plan, it is reported that there is a chance for reconstruction with the philosophy of "build back better" in line with EU environmental and energy policies [96]. In other words, instead of replacing the old one, the reconstruction should be replaced with higher performance, more environmentally friendly and more sustainable [104]. This is basically named as the Concept of reconstruction of buildings after major damage - Build-back strategy.

Figure 2 shows the concept of reconstruction after major damage caused by nature or man-made disaster. The level of performance within the life cycle of a building is gradually reduced due to wear and aging, and when it is reduced below the level set by regulations/standards, the required level needs to be increased by modernization over the standards as part of the upgrade. In the case of an extraordinary damage/disturbance, the level of functional properties may be significantly reduced to the limit, when the building is fundamentally damaged and basic functions are impaired, i.e. performance level of damage state. At this level, the building can often no longer be used, and it is necessary to proceed to a major modernization after the shock phase. Since often such modernization is very time-consuming and costly, it is possible to proceed in several successive stages. The individual phases must be designed in such a way that the subsequent phase could follow without major construction limitations.

In the first step (urgent actions) it is necessary to make the necessary adjustments to ensure the basic functions of the operation of the house. In the second phase (build-back) the modernization is aimed at achieving a quality level corresponding to the state before the damage. In view of the new quality requirements specified in the SDGs, the third step (build-better), should be set at a higher level of the building quality to meet the sustainability requirements.

For example, the "Energy security" Draft Plan states that there is an opportunity to increase energy efficiency in buildings by 13% by rebuilding buildings as NZEB and by thermal modernization of buildings in line with the EU [95]. In addition, within the scope of the EU integration process, there are advanced technology proposals such as smart preparation in line with the EU's 2030 and 2050 targets [50]. The smart readiness proposal is an attractive proposition to set the direction of key information about energy and water consumption of buildings, as well as issues such as policy development and education. Therefore, its inclusion in medium and long-term plans should be considered. However, the implementation of smart features means increased costs, which may not be suitable for a country at war. ***If the reconstruction is designed stepwise, the constructions are planned as "smart ready" in the emergency response step and the smart elements are completed in the medium to long term.***

In this context, it is recommended to prepare a handbook that will include reconstruction projects, architectural design solutions, project sketches and energy efficiency guidelines [93]. However, of course, this handbook should also be prepared by taking into account the regional differences and different objectives of the strategy, and it would be appropriate to divide the plan into steps in line with the "start now and increase gradually" view.

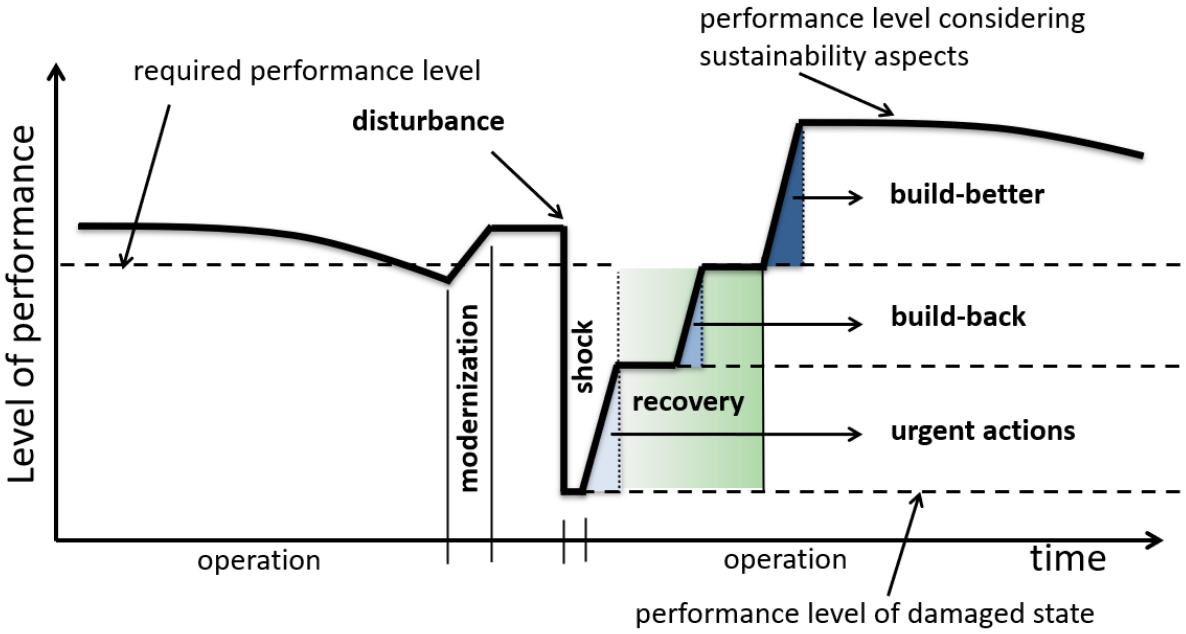

Figure 2 Build-back-better principles within reconstruction strategy

The draft plan "Reconstruction, urbanism, modernization of cities and regions" published by NCRU also provides guidance on some important technical issues. For example, modern, energy efficient and climate resilient reconstruction of social infrastructures such as outdated schools, kindergartens, and health facilities technically necessitates the consideration of climate zones. Region-specific planning of the reconstruction process to support the local economy, for example, designing the reconstruction of buildings with domestic products, increasing and using local and renewable energy sources, is a requirement of local and regional strategy. Therefore, a uniform approach to assessing the suitability of the performance of construction materials is recommended in Ukraine and EU member states [93]. Of course, such an assessment can easily be made by a special purpose third-party independent and international institution.

Inference 4: It is not possible to specify a uniform structure to make climate-resistant and energy-efficient sustainable buildings. Each building type has different needs. This requires consideration of typology for recovery.

4. Concluding Remarks

Various considerations warrant careful attention when contemplating construction projects. Firstly, the risk of demolition due to warfare poses a significant threat to any type of construction. Secondly, it is vital to allocate our limited resources wisely; prioritizing structures that not only restore social stability but also have the potential to generate income for future endeavors. Lastly, given the scarcity of resources, it becomes essential to distribute these resources judiciously among different projects. Taking these factors into account is crucial for effective and efficient reconstruction planning and resource management. Therefore, stepwise planning of reconstruction projects

will both increase the efficiency of utilization and contribute to allocate resources in the most appropriate way to all needs.

Four important bullets stand out within the scope of this study. These titles are visualized in Figure 3, each showing a different dimension. The proposed strategic reconstruction bullets include institutional, gradual, regional, and typical planning.

The Institutional bullet aims to establish a dedicated multi-partner institution to spearhead reconstruction, cutting through domestic politics and fostering global collaboration. This body, with international stakeholders, will drive the process with speed, transparency, and comprehensive reporting, crucial for effective recovery.

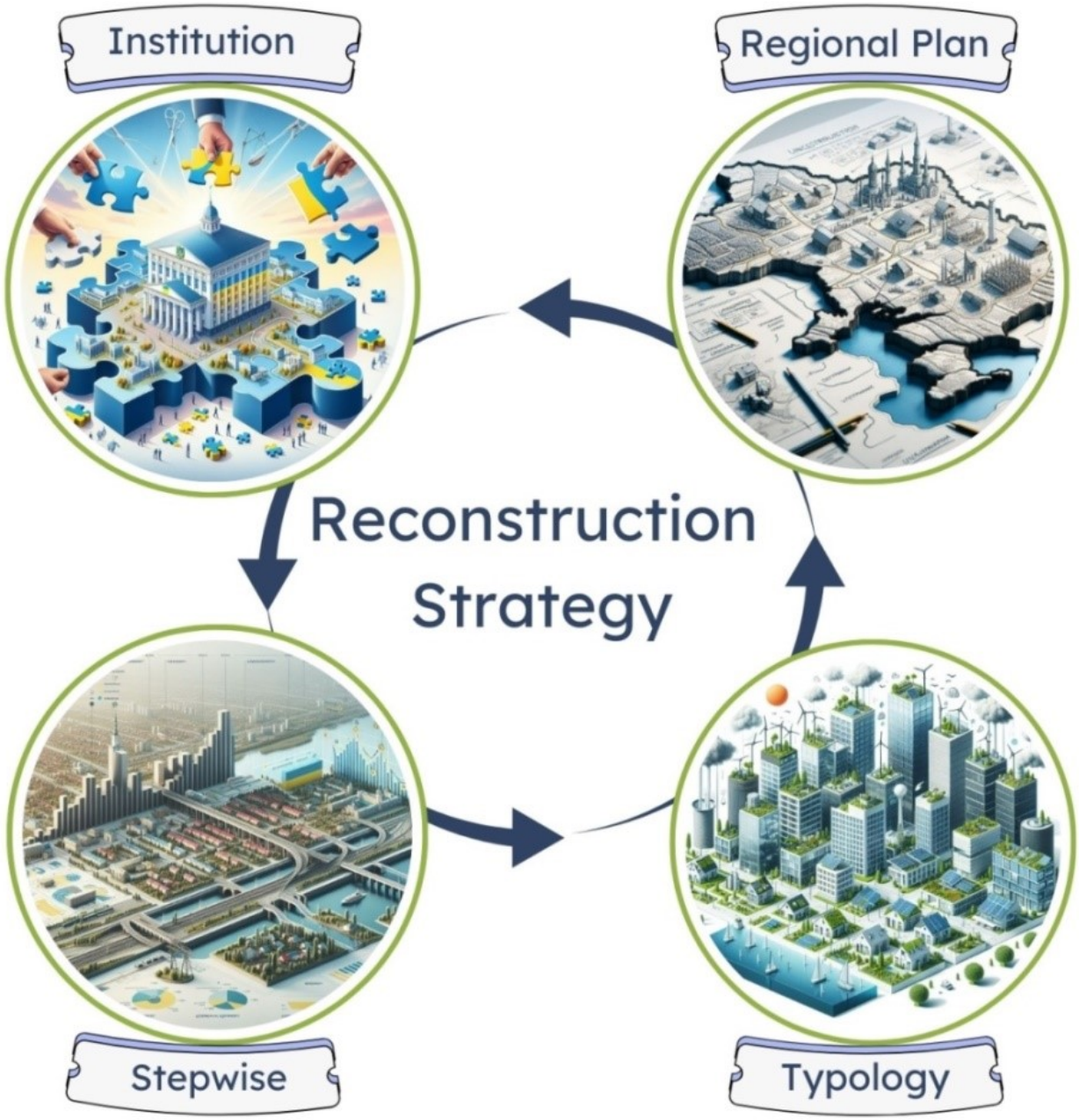

Figure 3 Reconstruction strategies (Powered by Microsoft Designer).

The stepwise bullet represents the urgent action step of the recovery process. Urgent action includes works that cannot be delayed despite the war. In this step, it can be planned enough to start social life. The immediate action step covers all building typologies, because demolished buildings negatively affect the morale and motivation of war-torn people. Therefore, this bullet involves rebuilding all types of buildings until they come into service. The second step is recommended to plan the reconstruction up to the required performance level. Considering that today's European Union legislation on building energy performance and that the reconstruction period may extend until 2050, it can be foreseen that the required performance level should be kept at the level of passive house standard. The third step describes the "Build Back Better" step, which is the final stage of reconstruction. Since zero emissions are targeted according to European legislation, it is recommended to target buildings that produce their own energy, i.e. zero energy buildings, for this step.

Another bullet in Figure 3 is the building typology. It is planned in line with the zero carbon target, except for some special building types, such as buildings used for historical and agricultural purposes. In other words, they are planned according to energy needs. Since the energy consumption of each building type is different, it is recommended to create a codex according to the building typology when planning the restructuring of the buildings. There are many types of buildings that serve society today such as; housings, educational facilities and public buildings. However, when making a national action plan, it may be appropriate to prepare a separate type of project for each building type.

Regionalism bullet means that buildings should be designed considering the needs and sensitivities of the region. The geographical features of the region are also the key parameters for the energy efficient (passive) design of the building. Passivation techniques such as Solar Wall, the building insulation type and thickness, window to wall ratio should be planned in accordance with the geographical conditions of the region. However, the size of the area (city) and the size of the service that building must provide guide the determination of the building's dimensions. In addition, it is extremely important that buildings are constructed using local materials, both to avoid "boom & boost" economy and to reduce carbon emissions. Therefore, the most important dimension of the reconstruction process that affects social and economic recovery is the regional planning.

Within the scope of this study, we have analyzed more than two hundred papers and identified three important factors for a sustainable and resilient reconstruction of Ukrainian Building stock. These factors can be adopted as a strategic roadmap for not only post-war reconstruction but all other anthropogenic and natural sustainable and resilient post-disaster reconstructions. The described reconstruction model is suitable for planning as emergency response and increase stepwise. The model considers regional characteristics, including materials, which is also suitable for regional development. Also, the proposed strategy is versatile and very useful, as it recommends planning for each building type separately.

5. Acknowledgement

This study has been supported by the Ministry of Education, Youth and Sports within project Mobilita ČVUT-VTA, registration number CZ.02.2.69/0.0/0.0/18_053/0016980.

6. References

[1] O. Khotynska-Nor and A. Potapenko, "Courts of Ukraine in Wartime: Issues of Sustainable Functioning," *Revista Juridica Portucalense*, vol. 31, no. 31, pp. 218–240, 2022, doi: 10.34625/issn.2183-2705(31)2022.ic-09.

[2] C. Halser and F. Paraschiv, "Pathways to Overcoming Natural Gas Dependency on Russia—The German Case," *Energies*, vol. 15, no. 14, pp. 1–24, 2022, doi: 10.3390/en15144939.

[3] M. Korneyev, I. Berezhniuk, V. Dzhyndzhoian, T. Kubakh, and K. Horb, "'Business marketing activities in Ukraine during wartime,'" *Innovative Marketing*, vol. 18, no. 3, pp. 48–58, 2022, doi: 10.21511/IM.18(3).2022.05.

[4] R. Quitzow, O. Renn, and Y. Zabanova, "The crisis in Ukraine: another missed opportunity for building a more sustainable economic paradigm," *GAIA - Ecological Perspectives for Science and Society*, vol. 31, no. 3, pp. 135–138, 2022, doi: 10.14512/gaia.31.3.2.

[5] O. Kotykova, O. Pohorielova, and M. Babych, "Key Aspects of the Relationship Between Sustainable Development Goals, Food Security and Agricultures in Ukraine," *European Countryside*, vol. 14, no. 4, pp. 721–752, 2022, doi: 10.2478/euco-2022-0036.

[6] G. Fotis, V. Vita, and T. I. Maris, "Risks in the European Transmission System and a Novel Restoration Strategy for a Power System after a Major Blackout," *Applied Sciences (Switzerland)*, vol. 13, no. 1, 2023, doi: 10.3390/app13010083.

[7] C. Kuzemko, M. Blondeel, C. Dupont, and M. C. Brisbois, "Russia's war on Ukraine, European energy policy responses & implications for sustainable transformations," *Energy Research & Social Science*, vol. 93, no. October, p. 102842, 2022, doi: 10.1016/j.erss.2022.102842.

[8] J. Korosteleva, "The Implications of Russia's Invasion of Ukraine for the EU Energy Market and Businesses," *British Journal of Management*, vol. 33, pp. 1678–1682, 2022, doi: 10.1111/1467-8551.12654.

[9] A. Borysenko, Y. Volko, O. Puskina, M. Potip, and Y. Leheza, "Regulatory principles of public administration in the field of state and regional environmental policy as part of the strategy for sustainable development of Ukraine," *Revista de la Universidad del Zulia*, vol. 13, no. 38, pp. 180–188, 2021, doi: 10.46925/rdluz.3512.

[10] World Bank, Government of Ukraine, European Union, and United Nations, "Ukraine Rapid Damage and Needs Assessment February 2022 – February 2023," 2023. doi: 10.1596/37988.

[11] X. Ma *et al.*, "Necessity of Post-War Renewal of University Teachers' Potential in Terms of Sustainable Development in Ukraine," *Sustainability (Switzerland)*, vol. 14, no. 19, pp. 1–19, 2022, doi: 10.3390/su141912598.

[12] I. Hasiuk, I. Darmanska, M. Mykhaskova, L. Pisotska, and O. Sukhovirskyi, "Assessment of Sustainable

Development of the Educational Sphere of Ukraine in the Paradigm of European Integration Processes," *Revista Românească pentru Educaţie Multidimensională*, vol. 14, no. 2, pp. 136–155, 2022.

[13] A. R. Szromek, B. Walas, and Z. Kruczek, "The Willingness of Tourism-Friendly Cities' Representatives to Share Innovative Solutions in the Form of Open Innovations," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 8, no. 3, p. 112, 2022, doi: 10.3390/joitmc8030112.

[14] M. Pugachov, V. Pugachov, O. Shevchenko, I. Banyeva, V. Kushniruk, and K. Shvets, "Perspectives for the Tourism and Hospitality Industry in a Globally Competitive Environment," *Economic Affairs (New Delhi)*, vol. 67, no. 5, pp. 907–914, 2022, doi: 10.46852/0424-2513.5.2022.26.

[15] H. Shevchenko and M. Petrushenko, "Rural Tourism within the Sustainable Development Goals: the Case of Ukraine," *SHS Web of Conferences*, vol. 95, p. 01004, 2021, doi: 10.1051/shsconf/20219501004.

[16] T. Sobchenko, T. Mykytsei, N. Zatsepina, A. Krushynska, and T. Samaricheva, "Analysis of Agritourism and Tourism Potential of Rural Areas in the System of Their Sustainable Development: a Case Study of Ukraine," *Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development*, vol. 22, no. 1, pp. 603–614, 2022.

[17] O. Shevchenko, S. Snizhko, S. Zapototskyi, H. Svintsitska, M. Matviienko, and A. Matzarakis, "Long-Term Analysis of Thermal Comfort Conditions During Heat Waves in Ukraine," *Geographia Polonica*, vol. 95, no. 1, pp. 53–70, 2022, doi: 10.7163/GPol.0226.

[18] A. Polyvianchuk, R. Semenenko, P. Kapustenko, J. J. Klemeš, and O. Arsenyeva, "The efficiency of innovative technologies for transition to 4th generation of district heating systems in Ukraine," *Energy*, vol. 263, no. October 2022, 2023, doi: 10.1016/j.energy.2022.125876.

[19] G. Yiasoumas, K. Psara, and G. E. Georghiou, "A review of Energy Communities: Definitions, Technologies, Data Management," *SyNERGY MED 2022 - 2nd International Conference on Energy Transition in the Mediterranean Area, Proceedings*, pp. 0–5, 2022, doi: 10.1109/SyNERGYMED55767.2022.9941441.

[20] G. Trypolska and O. Riabchyn, "Experience and Prospects of Financing Renewable Energy Projects in Ukraine," *International Journal of Energy Economics and Policy*, vol. 12, no. 1, pp. 134–143, 2022, doi: 10.32479/ijeep.11999.

[21] B. S. Soroka, K. Y. Pyanykh, and V. O. Zgurskyi, "mixed fuel for household gas-powered appliances as an option to replace natural gas with hydrogen," *Sci. innov.*, vol. 18, no. 3, pp. 10–22, 2022.

[22] N. Iwaszczuk, I. Zapukhliak, A. Iwaszczuk, O. Dzoba, and O. Romashko, "Underground Gas Storage Facilities in Ukraine: Current State and Future Prospects," *Energies*, vol. 15, no. 18, 2022, doi: 10.3390/en15186604.

[23] G. Trypolska and A. Rosner, "The Use of Solar Energy by Households and Energy Cooperatives in Post-War Ukraine: Lessons Learned from Austria," *Energies*, vol. 15, no. 20, 2022, doi: 10.3390/en15207610.

[24] G. Trypolska, T. Kurbatova, O. Prokopenko, H. Howaniec, and Y. Klapkiv, "Wind and Solar Power Plant End-of-Life Equipment: Prospects for Management in Ukraine," *Energies*, vol. 15, no. 5, pp. 1–15, 2022, doi: 10.3390/en15051662.

[25] G. Trypolska, S. Kyryziuk, V. Krupin, A. Wąs, and R. Podolets, "Economic Feasibility of Agricultural Biogas Production by Farms in Ukraine," *Energies*, vol. 15, no. 1, pp. 1–23, 2022, doi: 10.3390/en15010087.

[26] B. Steffen and A. Patt, "A historical turning point? Early evidence on how the Russia-Ukraine war changes public support for clean energy policies," *Energy Research and Social Science*, vol. 91, no. July, p. 102758, 2022, doi: 10.1016/j.erss.2022.102758.

[27] O. Brown, A. Froggatt, N. Gozak, N. Katser-buchkovska, J. Orysia Lutsevych, and A. Nixey, "The impact of Russia ' s war against Ukraine on climate security and climate action Independent Experts ' Analysis," 2023.

[28] V. Pichura, L. Potravka, N. Vdovenko, O. Biloshkurenko, N. Stratichuk, and K. Baysha, "Changes in Climate and Bioclimatic Potential in the Steppe Zone of Ukraine," *Journal of Ecological Engineering*, vol. 23, no. 12, pp. 189–202, 2022, doi: 10.12911/22998993/154844.

[29] P. Heidegger and I. Bakhturidze, "Comments and proposals regarding the theme of UNEA 6 from stakeholders in the European Region," no. January, 2023.

[30] P. Pereira, W. Zhao, L. Symochko, M. Inacio, I. Bogunovic, and D. Barcelo, "The Russian-Ukrainian armed conflict will push back the sustainable development goals," *Geography and Sustainability*, vol. 3, no. 3, pp. 277–287, 2022, doi: 10.1016/j.geosus.2022.09.003.

[31] A. Kuzior, I. Pidorycheva, V. Liashenko, H. Shevtsova, and N. Shvets, "Assessment of National Innovation Ecosystems of the EU Countries and Ukraine in the Interests of Their Sustainable Development," *Sustainability (Switzerland)*, vol. 14, no. 14, 2022, doi: 10.3390/su14148487.

[32] I. Bulakh, "Sustainable Development in the Context of the Architecture of Environmental Friendly Medical Centers in Rural Areas (Case for Ukraine)," *IOP Conference Series: Earth and Environmental Science*, vol. 1111, no. 1, 2022, doi: 10.1088/1755-1315/1111/1/012066.

[33] I. Zablodska, Y. Rohozian, O. Khandii, S. Sieriebriak, and I. Litvinova, "European Experience in the Construction of Territories with Special Economy Regime after an Armed Conflict: A Trajectory of Sustainability," *Problemy Ekorozwoju*, vol. 18, no. 1, pp. 51–60, 2023, doi: 10.35784/pe.2023.1.05.

[34] V. Koval, O. Borodina, I. Lomachynska, P. Olczak, A. Mumladze, and D. Matuszewska, "Model Analysis of Eco-Innovation for National Decarbonisation Transition in Integrated European Energy System," *Energies*, vol. 15, no. 9, pp. 1–19, 2022, doi: 10.3390/en15093306.

[35] M. Kryshtanovych, I. Dragan, D. Grytsyshen, L. Sergiienko, and T. Baranovska, "The Public and Environmental Aspect of Restoring Sustainable Regional Development in the Face of the Negative Impact of Military Actions on the Territory of the Country," *International Journal of*

Sustainable Development and Planning, vol. 17, no. 5, pp. 1645–1651, 2022, doi: 10.18280/ijsdp.170530.

[36] K. Mezentsev and O. Mezentsev, "war and the city : lessons from urbicide in Ukraine," *Czasopismo Geograficzne*, vol. 93, no. 2, pp. 495–521, 2022.

[37] S. Horbliuk, O. Brovko, and S. Kudyn, "Approaches To the Revitalization of Degraded Industrial Zones in Cities of Ukraine," *Baltic Journal of Economic Studies*, vol. 8, no. 1, pp. 36–42, 2022, doi: 10.30525/2256-0742/2022-8-1-36-42.

[38] I. Bulakh, T. Kashchenko, M. Harbar, V. Praslova, Y. Riabets, and V. Divak, "The Integrity of the Artistic Image of the City Based on Symbolization (the Case of Modern Architecture of Dnipro, Ukraine)," *Civil Engineering and Architecture*, vol. 10, no. 3, pp. 874–887, 2022, doi: 10.13189/cea.2022.100310.

[39] O. Borodina, L. Burdonos, V. Stetsenko, and O. Kovtun, "Sustainable Development Management Factors in The Regional Economy of Ukraine," *Economics. Ecology. Socium*, vol. 6, no. 4, pp. 14–26, 2022, doi: 10.31520/2616-7107/2022.6.4-2.

[40] M. Kichurchak, "Factors of Budgetary Funding for Higher Education in the European Countries in the Context of Sustainable and Human Development: Experience for Ukraine," *Financial and credit activity problems of theory and practice*, vol. 2, no. 43, pp. 279–287, 2022, doi: 10.55643/fcaptp.2.43.2022.3540.

[41] M. Mattera and F. Soto, "Dodging the bullet: overcoming the financial impact of Ukraine armed conflict with sustainable business strategies and environmental approaches," *Journal of Risk Finance*, pp. 122–142, 2022, doi: 10.1108/JRF-04-2022-0092.

[42] I. Semenenko, Y. Bilous, and R. Halhash, "The compliance of the regional development strategies and funding with the sustainable development concept: The case of Ukraine," *Green Finance*, vol. 4, no. 2, pp. 159–178, 2022, doi: 10.3934/gf.2022008.

[43] Y. Zaloznova, I. Petrova, and O. Serdiuk, "the Regime of International Private-Public Partnerships in Achieving the Sustainable Development Goals in Ukraine," *Baltic Journal of Economic Studies*, vol. 8, no. 1, pp. 55–61, 2022, doi: 10.30525/2256-0742/2022-8-1-55-61.

[44] A. Nagurney, "Operations Research for the Recovery and Reconstruction of Ukraine," *OR-MS Today*, vol. 49, no. 5, p. 18, 2022, [Online].

[45] I. Holovko and C. Haug, "Rebuilding Ukraine," 2023 Principles of a green post-war reconstruction. Berlin: adelphi consult GmbH.

[46] M. Zholobetska and A. Kotelenets, "Main Directions And Principles of The Reconstruction Plan of Ukraine," *Socio World*, vol. 09, no. 03, pp. 41–47, 2022.

[47] S. A. Mitoulis *et al.*, "Conflict-resilience framework for critical infrastructure peacebuilding," *Sustainable Cities and Society*, vol. 91, no. October 2022, p. 104405, 2023, doi: 10.1016/j.scs.2023.104405.

[48] A. Bieliatynskyi, S. Yang, V. Pershakov, M. Shao, and M. Ta, "Comparative analysis of the influence of various materials on the state of the roadside environment during the road repair," *Environmental Science and Pollution Research*, pp. 15523–15530, 2022, doi:

10.1007/s11356-022-23212-4.

[49] J. A. Dyczkowska and O. Reshetnikova, “Logistics Centers in Ukraine: Analysis of the Logistics Center in Lviv,” *Energies*, vol. 15, no. 21, pp. 1–15, 2022, doi: 10.3390/en15217975.

[50] O. Adegov, S. Shekhorkina, M. Babenko, M. Lyahovetska-Tokareva, and O. Kudryavcev, “Smart-Readiness Assessment of a Complex Residential Building in Ukraine,” *Slovak Journal of Civil Engineering*, vol. 30, no. 2, pp. 1–11, 2022, doi: 10.2478/sjce-2022-0009.

[51] P. Kulikov, O. Aziukovskyi, O. Vahonova, O. Bondar, L. Akimova, and O. Akimov, “Post-war Economy of Ukraine: Innovation and Investment Development Project,” *Economic Affairs (New Delhi)*, vol. 67, no. 5, pp. 943–959, 2022, doi: 10.46852/0424-2513.5.2022.30.

[52] G. C. Pascariu, P. Nijkamp, and K. Kourtit, “Regional Science Knowledge Needs for the Recovery of the Ukrainian Space-Economy: A Q-Analysis,” *Regional Science Policy & Practice*, no. January, pp. 75–94, 2023, doi: 10.1111/rsp3.12638.

[53] O. Bochko, N. Kosar, N. Kuzo, I. Bilyk, and O. Zarichna, “Determinants of Housing Construction in Ukraine,” *Real Estate Management and Valuation*, vol. 30, no. 3, pp. 1–11, 2022, doi: 10.2478/remav-2022-0017.

[54] A. Shcherbyna, “Towards a concept of sustainable housing provision in Ukraine,” *Land Use Policy*, vol. 122, no. September, p. 106370, 2022, doi: 10.1016/j.landusepol.2022.106370.

[55] L. Simkiv, U. Andrusiv, G. Kupalova, N. Goncharenko, O. Dzoba, and O. Yushkevych, “Concentration of Entrepreneurial Activity in the Regions of Ukraine in the Context of Sustainable Development,” *Financial and credit activity problems of theory and practice*, vol. 3, no. 44, pp. 347–356, 2022, doi: 10.55643/fcaptp.3.44.2022.3776.

[56] H. Denysyk, V. Kanskyi, V. Kanska, B. Denysyk, and M. Vinnytsia, “Anthropogenic Landscapes of Ukraine and Their Reconstruction,” *Czasopismo Geograficzne*, vol. 93, no. 3, pp. 417–433, 2022, doi: 10.12657/czageo-93-16.

[57] O. Kunakh, Y. Zhukova, V. Yakovenko, and O. Daniuk, “Influence of Plants on the Spatial Variability of Soil Penetration Resistance,” *Ekologia Bratislava*, vol. 41, no. 2, pp. 113–125, 2022, doi: 10.2478/eko-2022-0012.

[58] D. Breus and O. Yevtushenko, “Modeling of Trace Elements and Heavy Metals Content in the Steppe Soils of Ukraine,” *Journal of Ecological Engineering*, vol. 23, no. 2, pp. 159–165, 2022, doi: 10.12911/22998993/144391.

[59] O. Zhukov, O. Kunakh, N. Yorkina, and A. Tutova, “Response of soil macrofauna to urban park reconstruction,” *Soil Ecology Letters*, vol. 5, no. 2, 2023, doi: 10.1007/s42832-022-0156-0.

[60] C. Morar *et al.*, “Spatiotemporal Analysis of Urban Green Areas Using Change Detection: A Case Study of Kharkiv, Ukraine,” *Frontiers in Environmental Science*, vol. 10, no. March, pp. 1–27, 2022, doi: 10.3389/fenvs.2022.823129.

[61] V. Troian, V. Gots, E. Keita, N. Roussel, U. Angst, and R. J. Flatt, "Challenges in material recycling for postwar reconstruction," *RILEM Technical Letters*, vol. 7, pp. 139–149, 2022, doi: 10.21809/rilemtechlett.2022.171.

[62] I. Mikhno, N. Ihnatenko, O. Cherniaiev, V. Vynogradnya, D. Atstaja, and V. Koval, "Construction waste recycling in the circular economy model," *IOP Conference Series: Earth and Environmental Science*, vol. 1126, no. 1, p. 012003, 2023, doi: 10.1088/1755-1315/1126/1/012003.

[63] N. Khumarova and A. Krivenceva, "A Complex Systems Approaches to Sustainable Waste Management: the Case of a Recreational and Tourist Region of Ukraine," *Economics. Ecology. Socium*, vol. 6, no. 1, pp. 1–10, 2022, doi: 10.31520/2616-7107/2022.6.1-1.

[64] O. Kucher *et al.*, "Energy Potential of Biogas Production in Ukraine," *Energies*, vol. 15, no. 5, pp. 1–22, 2022, doi: 10.3390/en15051710.

[65] P. Skrypchuk, H. Shpak, V. Skrypchuk, and O. Gorodyska, "Business processes of digitalization of the agricultural land market in Ukraine," *IOP Conference Series: Earth and Environmental Science*, vol. 1126, no. 1, p. 012001, 2023, doi: 10.1088/1755-1315/1126/1/012001.

[66] L. Lingur, O. Martyniuk, I. Ivchenko, and O. Ivchenko, "Creating a Digital Space of Socially Sustainable Development for Food Enterprises," *Eastern-European Journal of Enterprise Technologies*, vol. 4, no. 13–118, pp. 22–33, 2022, doi: 10.15587/1729-4061.2022.263540.

[67] Martinho, V.J.P.D.; Cunha, C.A.d.S.; Pato, M.L.; Costa, P.J.L.; Sánchez-Carreira, M.C.; Georgantzís, N.; Rodrigues, R.N.; Coronado, F., "Machine Learning and Food Security: Insights for Agricultural Spatial Planning in the Context of Agriculture 4.0," *Applied Sciences (Switzerland)*, vol. 12, no. 22, 2022, doi: 10.3390/app122211828.

[68] T. Ben Hassen and H. El Bilali, "Impacts of the Russia-Ukraine War on Global Food Security: Towards More Sustainable and Resilient Food Systems?," *Foods*, vol. 11, no. 15, pp. 1–17, 2022, doi: 10.3390/foods11152301.

[69] M. Reho, J. Vilček, S. Torma, Š. Koco, A. Lisnyak, and R. Klamár, "Growing of the Containerized Seedlings of English Oak (Quercus robur L.) to Establish Sustainable Plantations in Forest-Steppe Ukraine," *Forests*, vol. 13, no. 9, pp. 1–11, 2022, doi: 10.3390/f13091359.

[70] A. Ohanisian, N. Levchenko, G. Shyshkanova, G. Abuselidze, V. Prykhodko, and O. Banchuk-Petrosova, "Organic farms are the fundamental basis for the sustainable foreign economic activities of agrarians in Ukraine," *Environmental and Socio-Economic Studies*, vol. 10, no. 2, pp. 49–61, 2022, doi: 10.2478/environ-2022-0011.

[71] Tetiana Shmatkvska, T. Kulinich, M. Dziamulych, S. Rogach, A. Bilochenko, and O. Serdiukova, "analysis of investment efficiency in the agricultural sector of ukraine on the basis of sustainable," *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, vol. 22, no. 3, pp. 649–658, 2022.

[72] M. Habrel, M. Kosmii, and M. Habrel, "Meritocentric Model of Spatial Development in Ukraine: Updating the General Scheme of Planning of the State Territory," *Spatium*, vol. 2, no. 47, pp. 21–31, 2022, doi: 10.2298/SPAT211123008H.

[73] V. S. Patsiuk, V. L. Kazakov, R. Skorupskas, I. O. Ostapchuk, and A. A. Petrova, "Revitalization of the industrial heritage: Guidelines for Kryvyi Rih," in *IOP Conference Series: Earth and Environmental Science*, 2022, vol. 1049, no. 1, pp. 1–18, doi: 10.1088/1755-1315/1049/1/012082.

[74] C. Huang *et al.*, "Mapping of nighttime light trends and refugee population changes in Ukraine during the Russian–Ukrainian War," *Frontiers in Environmental Science*, vol. 11, no. January, pp. 1–13, 2023, doi: 10.3389/fenvs.2023.1055100.

[75] O. Khotynska-Nor and N. Bakaianova, "Transformation of Bar in Wartime in Ukraine: on the Way To Sustainable Development of Justice (on the Example of the Odesa Region)," *Access to Justice in Eastern Europe*, vol. 5, no. 3, pp. 146–154, 2022, doi: 10.33327/AJEE-18-5.2-n000322.

[76] Q. Meng, "A new simple method to test and map environmental inequality: Urban hazards disproportionately affect minorities," *Land Use Policy*, vol. 122, no. July 2021, p. 106384, 2022, doi: 10.1016/j.landusepol.2022.106384.

[77] S. Modgil, R. K. Singh, and C. Foropon, *Quality management in humanitarian operations and disaster relief management: a review and future research directions*, vol. 319, no. 1. Springer US, 2022.

[78] M. Sapri and S. M. A. Razak, "Asset Management Recovery after the Disater: State of Knowledge," *MATEC Web of Conferences*, vol. 66, pp. 1–9, 2016, doi: 10.1051/matecconf/20166600067.

[79] M. Enshassi, K. Al-hallaq, and B. Tayeh, "Failure factors facing organizations in post-disaster housing reconstruction projects in Gaza Strip," *Civil Engineering Research Journal*, vol. 8, no. 5, pp. 1–10, 2019, doi: 10.19080/CERJ.2019.08.555750.

[80] K. N. Khalid, F. A. A. Nifa, R. M. Ismail, and C. K. Lin, "Initial findings on delay factors in the post-disaster housing reconstruction: Local authorities and NGOs perspectives," *Journal of Engineering Science and Technology*, vol. 12, no. Special Issue 4, pp. 137–146, 2017.

[81] D. Ismail, T. A. Majid, R. Roosli, and N. A. Samah, "Project Management Success for Post-disaster Reconstruction Projects: International NGOs Perspectives," *Procedia Economics and Finance*, vol. 18, no. September, pp. 120–127, 2014, doi: 10.1016/s2212-5671(14)00921-6.

[82] B. Hidayat and C. Egbu, "A literature review of the role of project management in post-disaster," *Proc. 26th annual ARCOM conference*, no. September, pp. 1269–1278, 2010.

[83] A. Himes-Cornell *et al.*, "Factors Affecting Disaster Preparedness, Response, and Recovery Using the Community Capitals Framework," *Coastal Management*, vol. 46, no. 5, pp. 335–358, 2018, doi: 10.1080/08920753.2018.1498709.

[84] J. da Silva, Z. Lubkowski, and V. Maynard, *Lessons from Aceh: Key Considerations in Post-Disaster Reconstruction*, no. January. 2010.

[85] D. Alexander, "Planning for post-disaster recostruction," *Duodecim; laaketieteellinen aikakauskirja*, vol. 111, no. 21, pp. 2078–83, 1995, [Online]. Available: http://www.ncbi.nlm.nih.gov/pubmed/9841166.

[86] A. Nejat and I. Damnjanovic, "modeling dynamics of post-disaster recovery," in *Construction Research Congress*, 2012, pp. 2200–2210.

[87] P. Fargues and C. Fandrich, "Europe Must Take on its Share of the Syrian Refugee Burden, But How?," *Opinions on the Mediterranean*, pp. 1–4, 2012.

[88] P. Aznar-Crespo, A. Aledo, J. Melgarejo-Moreno, and A. Vallejos-Romero, "Adapting social impact assessment to flood risk management," *Sustainability (Switzerland)*, vol. 13, no. 6, 2021, doi: 10.3390/su13063410.

[89] J. Schwab, K. C. Topping, C. C. Eadie, R. E. Deyle, and R. A. Smith, "Planning for Post-Disaster Recovery and Reconstruction," 1998.

[90] E. Passerini, "Disasters as agents of social change in recovery and reconstruction," *NATURAL HAZARDS REVIEW*, vol. 1, no. 2, pp. 67–72, 2000.

[91] E. Hayat and R. D. G. Amaratunga, "Road reconstruction in post - disaster recovery; the challenges and obstacles," in *International Conference on Building Resilience 2011: Interdisciplinary approaches to disaster risk reduction, and the development of sustainable communities and cities*, 2011, [Online]. Available: http://usir.salford.ac.uk/23372/.

[92] World Bank, "Ukraine Rapid Damage and Needs Assessment," 2022. doi: 10.1596/34401.

[93] NCRU, "Draft Ukraine Recovery Plan, Materials of the 'Construction, urban planning, modernization of cities and regions' working group," 2022.

[94] MPO, "National Energy Efficiency Action Plan of the Czech Republic on energy efficiency," 2014. [Online]. Available: https://ec.europa.eu/energy/sites/ener/files/documents/NEEAPCzechRepublic_en2014.pdf.

[95] NCRU, "Draft Ukraine Recovery Plan Materials of the 'Energy security' working group," 2022.

[96] NCRU, *Draft Ukraine Recovery Plan, Materials of the "European integration" working group*, no. July. 2022.

[97] EU CELEX_32010L0031, *on the energy performance of buildings*. 2010, p. L 153 / 13-35.

[98] EU CELEX_32018L0844, *amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency*, vol. 2018, no. May. 2018, pp. 75–91.

[99] EU CELEX_32012L0027, *on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC*, no. October 2010. 2012, pp. 1–56.

[100] S. J. Hogg, "Reconstruction Following Seismic Disaster in Venzone, Friuli," *Disasters*, vol. 4, no. 2, pp. 173–185, 1980, doi: 10.1111/j.1467-7717.1980.tb00271.x.

[101] P. R. Berke, J. Kartez, and D. Wenger, "Recovery after Disaster: Achieving Sustainable Development, Mitigation and Equity," *Disasters*, vol. 17, no. 2, pp. 93–109, 1993, doi: 10.1111/j.1467-7717.1993.tb01137.x.

[102] T. Becker *et al.*, *A Blueprint for the reconstruction of Ukraine*. CEPR Press, 2022.

[103] A. C. Osland, "Resolving land ownership issues for a community water project: A post-earthquake development dispute in rural El Salvador," *Planning Theory and Practice*, vol. 11, no. 1, pp. 47–63, 2010, doi: 10.1080/14649350903538046.

[104] A. Lupíšek, J. Růžička, J. Tywoniak, P. Hájek, and M. Volf, "Criteria for evaluation of resilience of residential buildings in central Europe," *International Review of Applied Sciences and Engineering*, vol. 9, no. 2, pp. 89–93, 2018, doi: 10.1556/1848.2018.9.2.2.