Ukraine's Green Reconstruction: Environmental Challenges and EU Integration Opportunities

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Abstract

Ukraine's reconstruction must follow a sustainable path, not only to restore destroyed infrastructure but also to secure long-term competitiveness, energy security, and progress toward EU accession. This study examines the challenges and opportunities of post-war "green reconstruction," defined here as a strategy that integrates decarbonization, circular economy practices, biodiversity restoration, and energy efficiency. This definition is adopted to ensure consistency with the European Green Deal pillars and with international climate and biodiversity commitments. The analysis highlights how environmental damage caused by the war interacts with pre-existing structural weaknesses, such as dependence on heavy industry, outdated infrastructure, and limited policy implementation. Drawing on official reports, EU and UN documents, and recent peer-reviewed research, the paper explores issues of pollutant emissions, waste and natural resource management, and the implications of the European Green Deal. Findings indicate that over 230 million tons of greenhouse gases were released in the first three years of the war, while at least US$35 billion in renewable energy investment will be required to meet climate targets. The study argues that reconstruction cannot be separated from European integration: achieving sustainability will demand comprehensive institutional reforms, stronger public participation, and close international cooperation, including concrete measures such as rapid ETS alignment, CBAM adaptation for industry, and mandatory circularity in reconstruction contracts.

Keywords: green reconstruction, sustainability, EU integration, circular economy, energy security

JEL codes: F15, O52, Q01, Q54

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Introduction

The trajectory of Ukraine's reconstruction will determine whether the country locks itself into outdated and polluting infrastructure or advances toward sustainable development. Ukraine's future prosperity and EU accession depend on making sustainability the core principle of reconstruction – not as an add-on, but as the decisive condition for competitiveness, security, and legitimacy. If environmental considerations are neglected, Ukraine risks losing export competitiveness under the EU's Carbon Border Adjustment Mechanism (CBAM) and undermining its long-term energy security. Conversely, embedding European Green Deal principles into reconstruction provides an opportunity to build a resilient, low-carbon economy and to strengthen the country's prospects for EU accession.

Since the full-scale Russian invasion of February 2022, Ukraine has suffered devastating economic and social losses. At the same time, the war has generated environmental consequences of global significance, from widespread land degradation to massive greenhouse gas releases. The scale of damage remains difficult to assess due to the ongoing fighting, but costs are rising daily. Ecosystem losses have affected forests, grasslands, national parks, wetlands, and agricultural land (Cabinet of Ministers of Ukraine, 2025a). As of March 2025, an estimated 174,000 square kilometres of land are contaminated with mines and unexploded ordnance, obstructing both ecological recovery and agricultural production (Ministry of Defence of Ukraine, 2025). Mine clearance alone may cost tens of billions of dollars, while the restoration of ecosystems will require decades of rehabilitation.

The environmental damages are multifaceted:

- **Biodiversity loss:** often irreversible, exemplified by the June 2023 destruction of the Nova Kakhovka hydroelectric power plant and dam, which wiped out wetlands and floodplain forests valued at 146 billion hryvnia (≈ €3.6 billion).
- **Water pollution:** more than 90,000 tons of heavy metals, nitrates, and organic pollutants have entered the Dnieper basin and Black Sea, exceeding permissible limits 10–40 times (Greenpeace, 2024).
- **Soil and agriculture:** over 20% of farmland is contaminated with diesel, explosives, and heavy metals, causing estimated losses of 180 billion hryvnia (≈ €4.4 billion) (Ministry of Agrarian Policy, 2024).
- **Air quality and emissions:** more than 230 million tons of CO_2e were released along major industrial frontlines between 2022 and 2024 (Ministry of Environmental Protection, 2025b).
- **Energy infrastructure:** more than 50 thermal and hydro power plants and substations were destroyed; by late 2024, 60% of capacity was unusable or unstable, with reconstruction needs exceeding US$58 billion (Cabinet of Ministers, 2025).

According to joint estimates by the World Bank, the United Nations, and the European Commission, the total cost of reconstruction stands at approximately US$524 billion (Cabinet of Ministers of Ukraine, 2024a). Environmental damage alone has been recorded in at least 2,364 cases, with total costs exceeding US$52.4 billion (Ministry of Environmental Protection and Natural Resources of Ukraine, 2025a).

In response, Ukraine has elevated environmental protection and ecosystem-based restoration as strategic priorities, alongside the recovery of energy, transport, education, and health systems. The government has adopted "ecological security" as a guiding principle, requiring all new investments to align with the European Green Deal. Strategic goals include achieving climate neutrality by 2060, phasing out coal by 2035, and introducing an EU-style integrated permitting system for industrial emissions by 2025. Compared to the EU, however, Ukraine remains behind: the EU target is climate neutrality by 2050 (a decade earlier), most member states plan coal phase-out by 2030 (five years sooner), and the EU Emissions Trading System has been operational since 2005, while Ukraine is only preparing ETS alignment. This gap illustrates both the scale of the challenge and the urgency of reforms.

In this study, green reconstruction is understood as a comprehensive approach that integrates four pillars: decarbonization, circular economy, biodiversity restoration, and energy efficiency. These elements were selected because they mirror the European Green Deal priorities and directly address Ukraine's structural weaknesses, such as high energy intensity, coal dependence, and ecosystem degradation. While the ecological destruction represents an immense loss, it may also serve as a catalyst for systemic reforms. Reconstruction provides a unique opportunity to embed sustainability at the core of economic recovery and accelerate EU integration.

Against this background, the central research question of this study is: how can Ukraine align post-war reconstruction with the European Green Deal to achieve climate neutrality, environmental security, and EU integration? To answer this question, the analysis relies on a qualitative review of literature and policy documents published between 2023 and 2025. Sources were selected for their timeliness, reliability, and direct relevance to European integration, with priority given to official reports from Ukrainian government agencies (e.g., Ministry of Environmental Protection and Natural Resources, Ministry of Energy, Cabinet of Ministers), the European Commission, the World Bank, and UN agencies, complemented by recent peer-reviewed articles. This ensures that the findings are both scientifically grounded and aligned with policy debates. The study deliberately refrains from providing in-depth sectoral case studies (e.g., district heating, agriculture), as these would require separate empirical research. Instead, sectoral dynamics are addressed in a diagnostic way to illustrate systemic challenges, while the primary focus remains on the strategic and institutional alignment with the European Green Deal. The aim is not to provide a full inventory of war-related ecological damage, but to identify concrete policy pathways that can reconcile urgent reconstruction needs with long-term sustainability and EU accession.

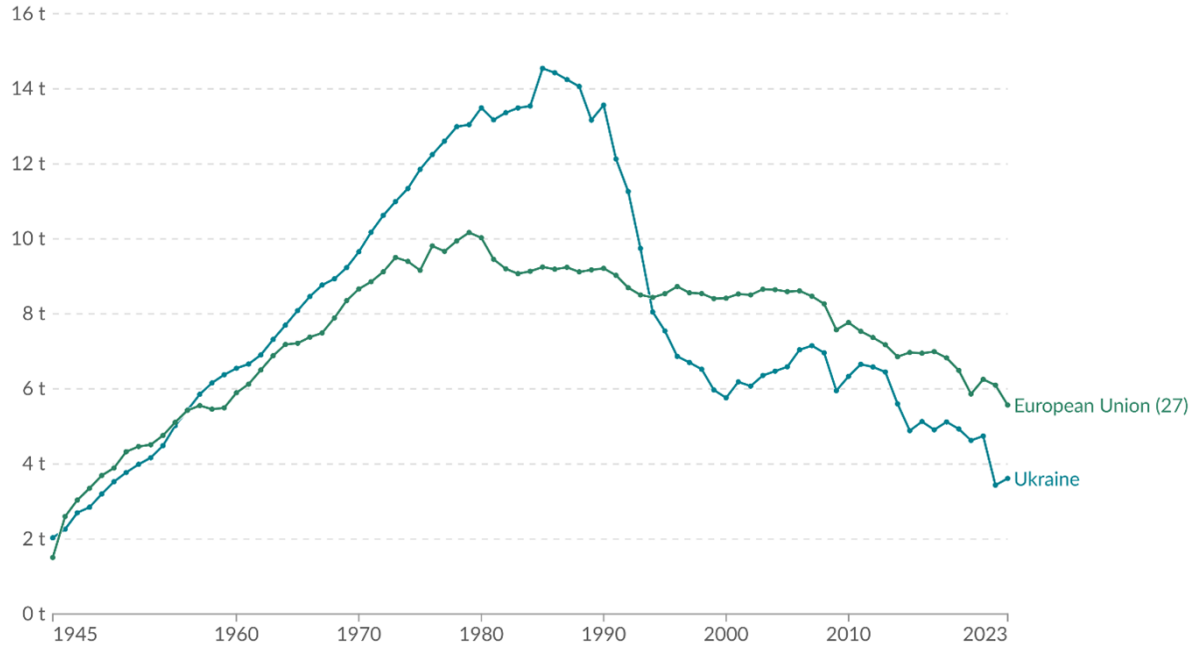
1. Environmental and sustainability challenges in Ukraine before the war

Even before Russia's full-scale aggression, Ukraine faced deep-seated sustainability challenges. The economy remained heavily dependent on energy- and resource-intensive sectors such as heavy industry and intensive agriculture, which placed severe pressure on natural resources and ecosystems. Chronic environmental pollution, inefficient resource management, and weak regulatory enforcement undermined long-term ecological resilience, while climate policy responses delivered only limited results. These vulnerabilities were compounded by outdated, energy-intensive industrial infrastructure, underdeveloped water management systems, and the overuse of soil and water resources.

1.1. Energy dependence and CO_2 emissions in Ukraine before the war

Ukraine's pre-war emission profile was determined by its reliance on energy- and resource-intensive sectors, particularly heavy industry and intensive agriculture. This structural dependence, combined with outdated infrastructure, inefficient resource management, and underdeveloped water systems, placed a significant burden on ecosystems and shaped the country's greenhouse gas trajectory.

Figure 1. CO_2 emissions per capita in Ukraine and the European Union (1945–2023)



Source: Edited by the author based on Our World in Data (2024)

Between 1990 and 2017, total CO_2 emissions declined by more than 60%, but this reduction was driven mainly by deindustrialisation and capacity loss rather than deliberate decarbonization policies (Sobolieva, 2023; Khaustova & Kovalova, 2020). Figure 1 illustrates these dynamics, showing that while per capita emissions in Ukraine dropped sharply after the 1990s, in 2020 they stood at about 4.2 tCO_2 per person compared to 6.3 tCO_2 in the EU. However, the underlying reasons differ fundamentally: Ukraine's decline was the result of economic collapse and capacity loss, whereas the EU's reduction stemmed from structural reforms, energy efficiency gains, and renewable deployment.

Coal-fired power generation remained dominant until 2020, while the share of renewables continued to lag far behind the EU average. According to the IEA, in 2020, Ukraine's primary energy supply consisted of approximately 29% natural gas, 28% coal, 24% nuclear, and only about 7% renewables (IEA, 2022). In contrast, within the EU, fossil fuels accounted for around 67% of total energy supply, while renewables represented 19.5%, respectively (Eurostat, 2025). Strong regional disparities also persisted: eastern industrial regions, especially Donbas and Dnipropetrovsk, relied heavily on coal, whereas western Ukraine depended more on biomass and decentralised heat production (USGS, 2020).

The development of Ukraine's climate policy framework was slow and inconsistent. The first environmental action plan was adopted only in 1998 and suffered from a persistent gap between ambitions and implementation (Ministry of Environmental Protection, 2003). More meaningful progress came after the 2014 Association Agreement with the EU, which led to the 2016 climate policy concept (targeting a 40% reduction by 2030 compared to 1990) and the updated 2021 NDC that committed to limiting emissions to no more than 35% of the base year level by 2030, with carbon neutrality by 2060 (UNFCCC, 2021). Yet implementation mechanisms remained weak. The MRV system, launched in 2019, functioned only partially, and a national emissions trading system was not established by 2022 (Energy Community, 2021; ICAP, 2024). In parallel, fossil fuel subsidies amounting to 5–6% of GDP annually continued to distort market incentives and slowed down investments in renewable energy and efficiency (OECD, 2023).

At the sectoral level, the energy sector accounted for around 65% of national greenhouse gas emissions in 2020 (UNFCCC, 2021). More than 12 GW of outdated coal capacity generated significant particulate matter and carbon dioxide emissions, with limited flexibility in managing fluctuations in energy demand (IEA, 2022). The industrial sector – particularly steel, cement, and chemicals – was similarly emission-intensive, with only modest efficiency investments by major companies such as Metinvest (Metinvest, 2024). Other large industrial emitters, such as ArcelorMittal Kryvyi Rih, ranked among the biggest single-site CO_2 sources in Eastern Europe, underlining Ukraine's exposure to the EU's Carbon Border Adjustment Mechanism. Agriculture contributed around 14% of national emissions, above the EU average, driven by livestock, manure management, and fertiliser use (OECD, 2023). Waste management remained underdeveloped, with methane emissions primarily from uncontrolled landfills (UNFCCC, 2021), while the LULUCF sector functioned as a net emitter due to illegal logging and agricultural expansion (Green Deal Ukraine, 2024).

In international comparison, Ukraine was a medium-sized emitter in absolute terms but significantly above the EU average in energy intensity and emissions per GDP. In 2020, the country used nearly three times more energy to produce one unit of GDP than the EU average (Energy Community, 2020). This extreme energy intensity, coupled with outdated technology and persistent subsidies, meant that emissions remained closely tied to economic growth, in contrast to the gradual decoupling observed in the EU (OECD, 2021). Table 1 summarises these differences between Ukraine and the EU. Ukraine lagged in virtually every dimension: slower coal phase-out, weaker institutional frameworks, lower renewables, and higher energy intensity.

Table 1. Ukraine and the EU: Pre-war Energy and Climate Comparison

Indicator	Ukraine	European Union (EU-27)
Climate neutrality target	2060 (NDC 2021)	2050 (EU Climate Law)
Coal phase-out	2035 (announced)	2030 (most MS)
ETS	Not established (MRV partial since 2019)	Operational since 2005
Energy intensity (toe/1000 USD GDP, PPP)	≈ 3× EU average	Baseline
Primary energy mix	29% natural gas, 28% coal, 24% nuclear, ~7% renewables	~67% fossil fuels, ~13% nuclear, ~20% renewables
CO_2 emissions per capita	~4-5 tCO_2	~6–7 tCO_2
Agriculture's share of GHG emissions	~14%	~10%
Waste sector	Landfill-dominated, high methane, no EPR	Widespread recycling, EPR in force
LULUCF	Net emitter (deforestation, soil degradation)	Net sink

Source: Edited by the author based on UNFCCC (2021), Cabinet of Ministers of Ukraine (2021), Energy Community (2020, 2021), IEA (2022), ICAP (2024), Eurostat (2025), Our World in Data (2024), OECD (2023), Green Deal Ukraine (2024)

Ukraine entered the war with structural dependence on coal and heavy industry, weak policy implementation, and high energy intensity, leaving it lagging behind European climate ambitions and ill-prepared for a rapid green transition. The outbreak of the full-scale war in 2022 not only aggravated these pre-existing vulnerabilities but turned them into amplifiers of environmental damage: coal-based and centralised energy infrastructure became direct military targets, and the absence of a functioning MRV/ETS system made it harder to quantify losses and mobilise green finance for recovery.

1.2. Agricultural sustainability, soil degradation, and water management

After the collapse of the Soviet Union, Ukraine's agricultural system shifted from collective farms to privatised structures, but this transition paid little attention to environmental sustainability. The abolition of soil monitoring systems and the weakening of central oversight encouraged unsustainable practices such as excessive mechanisation, monoculture farming, and the abandonment of crop rotation. As a result, humus levels dropped drastically – by up to 70% in some areas – while an estimated 32–33 million tons of soil were lost each year due to erosion (FAO, 2012; UNCCD, 2019).

Water management faced similar challenges. Most irrigation systems, dating back to Soviet times, were technically obsolete and suffered from poor maintenance. Overuse, leaky canals, and ageing infrastructure reduced efficiency and aggravated salinisation. Although Ukraine declared its intention to align with the EU Water Framework Directive after 2014, regulatory enforcement remained weak compared to the EU's binding nitrate and soil directives, which helped keep erosion and nutrient pollution at levels well above the European average (OECD/FAO, 2023).

The 2014 conflict in eastern Ukraine sharply worsened the situation (Tankovsky, 2020). The destruction of industrial facilities caused heavy metal and fuel contamination in rivers such as the Dnieper and Donets, while unregulated cultivation, deforestation, and fragmented land ownership accelerated soil degradation (Washington Post, 2025; Tsymbaliuk et al., 2025). At the same time, supply chain disruptions increased the use of unregulated agrochemicals, while mined agricultural land further reduced safe cultivation areas.

Efforts to introduce Land Degradation Neutrality targets after 2020, aiming to restore 8–15 million hectares, reflected closer EU alignment, but implementation was hampered by a lack of funding, weak institutions, and limited monitoring capacity (UNCCD, 2019; Bavrovska, 2022). By 2022, Ukraine's soil and water use had reached a structurally unsustainable state: erosion, salinisation, nitrate and phosphate pollution, and heavy metal accumulation undermined both food security and public health, especially in rural areas (FAO & World Bank, 2012; Romero et al., 2024).

In this context, agriculture remained highly vulnerable. More than half of arable land was intensively cultivated, pushing back natural steppe ecosystems and disrupting soil formation cycles. The fertility of the famous chernozem soils declined due to erosion and nutrient depletion, while high nitrogen and phosphorus inputs caused eutrophication and fish mortality in key basins such as the Dnieper, Donets, and Irpin. Without systemic reforms, these pressures risked not only ecological stability but also Ukraine's long-term export competitiveness.

Sustainable solutions will require integrated measures in soil conservation, irrigation modernisation, and regulatory enforcement. Precision agriculture, digital soil monitoring, and EU-backed investment in green technologies offer opportunities, but success will depend on institutional reforms, effective mine clearance, and harmonisation with EU strategies such as the Farm to Fork Strategy and the EU Soil Strategy 2030 (Petrychenko et al., 2022; Martynyuk, 2024).

1.3. Waste management issues

Ukraine's waste management system has undergone a long and often contradictory development since independence in 1991. The legacy of the Soviet period, the dominance of industrial structures, and the weakness of environmental institutions all contributed to waste management systems being sidelined during the post-socialist transition and only marginally linked to public policy reform processes. Waste generation levels have been extremely high since the early 1990s: extractive sectors such as coal mining, metallurgy, chemicals, and construction have produced extreme amounts of waste, which has often been managed in technologically outdated and environmentally hazardous ways. According to 2018 statistics, the country's total waste output reached 12.9 billion tons, of which more than 90% was industrial in origin, and only 26% was recycled in some form, while the remaining 74% was landfilled (Deineko et al., 2019; Linde et al., 2024).

The amount of municipal solid waste ranged between 10 and 11 million tons per year, which was well above the European average. More than 90% of municipal waste ended up in landfills, and the recycling rate was only 8.24% in 2020 (Kaletnik et al., 2022; Nikishyna et al., 2024), compared to nearly 49% in the EU the same year (Eurostat, 2023). The prevalence of selective household waste collection remained extremely low, and there was no demand for secondary raw materials in the processing industry, which made it practically impossible to implement the principles of a circular economy (Synchanskyy, 2025). The infrastructure for selective waste collection – especially collection points, containers, and transport logistics – was severely lacking, which led to household waste being burned or illegally dumped, especially in rural areas (Kotsiuba et al., 2023).

The management of hazardous waste was a particularly critical issue during the period under review. A large number of industrial facilities, especially in eastern and southern Ukraine, emitted significant amounts of toxic substances, sludge, and waste contaminated with heavy metals. These were often disposed of improperly, buried in the ground or placed in inadequately insulated landfills, causing serious soil and water pollution and posing significant public health risks (Synchanskyy, 2025; Makovetska and Omelyanenko, 2014).

In the 1990s, the regulatory framework for waste management still followed the normative regulatory logic inherited from the Soviet era, and it was only in the mid-2000s that a gradual convergence with European Union guidelines began. The first substantive reform measures on waste management aimed to harmonise Directive 2008/98/EC and Directive 2010/75/EU on industrial emissions, but their practical implementation was delayed for a long time (Shpak et al., 2020). The 2021 Law on Waste Management was the first comprehensive regulatory breakthrough that established the waste hierarchy, the application of EPR (Extended Producer Responsibility), and the need to develop a digital waste information system in line with the principles of the circular economy (Nikishyna et al., 2024; Synchanskyy, 2025). The stated aim of the law was full EU harmonisation and alignment with the

European Green Deal, but the implementing regulations, data collection standards, and sanction mechanisms necessary for implementation were still in the preparatory phase in 2022 (Kuzub et al., 2025).

At the institutional level, waste management was both underfunded and fragmented. The role of central environmental authorities changed inconsistently depending on political cycles and administrative reforms, while practical implementation was largely the responsibility of local governments. Although decentralisation reforms (Tankovsky & Rati, 2025) aimed to strengthen local competencies on paper, in reality, these municipalities often lacked the financial resources, human resources, or technical means to perform waste management tasks (Elrabay'a and Marchenko, 2021; Kaletnik et al., 2022). The central-local relationship was often characterised by overlapping responsibilities, coordination deficiencies, and uncertainty in the interpretation of laws, which, in the long run, hindered the development of a unified regulatory system.

In terms of infrastructure, Ukraine lagged far behind not only the EU average but also the regional average during the period under review. Before 2022, there were approximately 782 official waste treatment facilities operating in the country, with an annual capacity of around 15.9 million tons (Kaletnik et al., 2022). However, most of these used outdated technology, in many cases did not have operating licenses, or did not comply with EU regulations. The infrastructure for selective collection was of poor quality, and no national logistics network had been established for the efficient transport and processing of materials. Most landfills did not meet environmental requirements: they did not have adequate insulation layers, leachate collection systems, or monitoring devices, which resulted in serious soil and water pollution in the long term (Linde et al., 2024).

Although the introduction of digital technologies and systems for tracking waste flows appeared in policy documents, practical implementation stalled in the pilot phase. The toolkit for data-driven waste management, including digital collection logistics, waste generation mapping, and the use of artificial intelligence, has only been tested in limited areas, typically within the framework of international donor programs (Kotsiuba et al., 2023). Structural problems were further exacerbated by low private investment appetite, driven by weak legal certainty, corruption risks, and lack of investor confidence (Deineko et al., 2019; Kuzub et al., 2025).

The social dimension was not without its problems either. The population's environmental attitudes, waste awareness, and level of participation in selective collection remained low until the end of the period under review. The reasons for this included a lack of environmental education and information campaigns, distrust of public services, and low levels of community participation mechanisms (Nikishyna et al., 2024). The role of civil society remained marginal, with only a few regions seeing the emergence of NGOs or local initiatives actively promoting waste management reform.

Ukraine's waste management system, therefore suffers from structural, legal, technological, and social shortcomings. The 2021 regulatory reform and the waste management strategy for 2030 were important steps towards sustainability, but

practical implementation, financing, institutional capacity, and a lack of public awareness continue to pose serious obstacles to the green transition. These systemic weaknesses were further aggravated by the destruction of waste infrastructure during the war, which increased illegal dumping and uncontrolled burning.

2. Environmental policy and administration in Ukraine

Ukraine's environmental governance has evolved since independence, but has been marked by institutional instability, fragmented sectoral policies, and weak enforcement. Environmental protection consistently ranked below economic recovery in political priorities, and systemic obstacles limited the implementation of international commitments such as the Aarhus Convention and the Sustainable Development Goals (UNECE, 2016).

The Ministry of Environmental Protection and Natural Resources (MENR) has undergone repeated reorganisations, undermining strategic planning and continuity (OECD, 2022a). Despite decentralisation reforms, regional and local bodies remained underfunded and weak (UNDP Ukraine, 2021). The 1991 Law on Environmental Protection provided the legal foundation, but became outdated and incoherent, with overlapping sectoral regulations and limited enforcement capacity.

A turning point came with the 2014 EU–Ukraine Association Agreement, which required alignment with 17 environmental directives, including those on water, air quality, environmental impact assessment (EIA), and Natura 2000 (European Commission, 2014). Important progress followed: a new EIA law was adopted in 2017, and a State Ecological Inspectorate was established in 2018. However, implementation was inconsistent: EIA procedures were often formalistic, public participation remained weak, and integrated pollution prevention (IPPC) and industrial emissions (IED) compliance lagged far behind EU timelines (UNECE, 2021). Carbon pricing and an Emissions Trading System remained only at the planning stage (ICAP, 2024).

Strategic documents such as the "Low Emission Development Strategy 2050" and the "Climate Change Adaptation Strategy 2030" signalled ambition, but their impact was limited by budgetary constraints, low international financing, and the lack of cross-sectoral integration (OECD, 2022b). Principles of environmental democracy, while embedded in law, were weak in practice: transparency was inconsistent, civil society participation limited, and enforcement agencies under-resourced (UNDP Ukraine, 2021).

By 2021, Ukraine had achieved formal progress in EU legal harmonisation, particularly in water and air quality, but deficits in implementation, financing, and institutional capacity persisted. The full-scale invasion in 2022 further undermined governance: environmental inspections collapsed, funding shifted to defence, and EU harmonisation slowed significantly. In the post-war period, reconstruction will require not only physical rebuilding but also institutional strengthening, transparency, and alignment with the EU Green Deal to ensure resilience and long-term sustainability.

2.1. Challenges and progress in EU legal harmonisation in Ukraine

Ukraine's political turnaround in 2014, following the Maidan revolution and subsequent Russian aggression, reoriented the country's geopolitical trajectory towards the European Union. The EU-Ukraine Association Agreement (AA) of 27 June 2014, together with the Deep and Comprehensive Free Trade Area (DCFTA), set the framework for far-reaching legal and institutional reforms, including in environmental protection (European Commission, 2014). However, implementation of the environmental chapters faced major obstacles from the outset, primarily due to weak administrative capacity, chronic underfunding, and fragmented institutions.

The environmental provisions of the AA required gradual approximation to more than 30 EU directives, covering water and air quality, waste management, industrial emissions, and biodiversity. Yet alignment was uneven and often ad hoc, without generating systemic change. For example, the Ministry of Ecology and Natural Resources (MEPNR), established after 2014, shared key powers with the Ministries of Agriculture, Health, and Energy, which hindered policy coordination and produced conflicting sectoral strategies (UNECE, 2017).

Financial constraints were another critical barrier. Between 2014 and 2020, environmental spending averaged less than 0.5% of GDP, while compliance with EU standards would have required massive investment in waste treatment, water purification, and air pollution control (OECD, 2023). In the waste sector, over 90% of landfills failed to meet EU safety standards, and selective collection rates remained below 5% in 2020 (State Statistics Service of Ukraine, 2021).

The EU provided financial and technical support through EU4Environment, Twinning, TAIEX, and ENI, but assistance was fragmented and poorly integrated into long-term strategies. National plans – such as the introduction of IPPC licensing, ecological tax reform, or industrial emissions regulation – often stalled in the legislative process or lacked enforcement mechanisms (Energy Community, 2020).

Progress was therefore largely formal rather than substantive. Air quality regulation illustrates this gap: although Ukraine adopted a national air pollution plan in 2018, alignment with the IED and NEC directives was undermined by the absence of monitoring and reporting systems and the failure to establish a transparent emissions database (European Environment Agency, 2020). Enforcement remained weak, as most industrial plants lacked modern purification equipment, and coal-fired power stations exceeded EU emission limits severalfold (Bankwatch, 2020).

The broader political and social context further complicated reforms. Decentralisation after 2014 gave local governments greater autonomy, but most municipalities lacked the financial and professional capacity to implement EU-driven environmental measures (UNECE, 2017). Regulatory fragmentation, uneven enforcement, and local disparities emerged in waste management, water policy, and land use.

Finally, institutional corruption and low transparency undermined trust. Environmental permitting procedures – particularly EIA and SEA – were often formalities, with limited opportunities for meaningful participation. Although access to information was legally guaranteed after 2015, data were often incomplete, delayed, or unreliable (Transparency International Ukraine, 2021).

EU legal harmonisation in Ukraine advanced primarily on paper. While directives were transposed and strategies drafted, practical implementation remained partial, fragmented, and underfunded. By 2022, progress in aligning with the EU acquis had laid the groundwork for future reforms, but systemic deficits in enforcement, financing, and institutional stability continued to undermine regional effectiveness (Tankovsky et al, 2025). The war has further stalled these processes, making post-war reconstruction a critical window for embedding EU Green Deal principles – climate neutrality, circular economy, and biodiversity protection – into Ukraine's environmental governance.

3. Ukraine's integration into the EU Green Deal framework

The European Green Deal is a comprehensive policy initiative adopted by the European Commission on December 11, 2019, with the aim of making Europe the first climate-neutral continent by 2050 (European Commission, 2019a).

The central element of the Green Deal is the climate neutrality target set for 2050, which has been elevated to legal status by the European Climate Regulation (Regulation (EU) 2021/1119). This target means that greenhouse gas emissions and removals in the EU will be balanced by 2050 (European Union, 2021). The Circular Economy Action Plan (CEAP), adopted in March 2020, also plays an important role in the plan (European Commission, 2020a). The CEAP aims to establish a sustainable value chain covering the entire life cycle of products, to prevent waste, and to encourage eco-design and recycling. Focus areas include electronics, textiles, construction, and plastics.

In order to achieve climate neutrality, comprehensive reforms have been launched in energy policy under the Green Deal, particularly in the areas of increasing the share of renewable energy sources and improving energy efficiency. The EU's goal is for at least 42.5% of energy consumption to come from renewable sources by 2030 (European Commission, 2023). In addition, hydrogen technology, energy storage, and electrification have also been given a key role in the implementation of the Green Deal. The Green Deal also places great emphasis on sustainable mobility. The sustainable and smart mobility strategy adopted in December 2020 aims to decarbonise transport, including the spread of electric vehicles, the development of public transport, and the promotion of digital mobility solutions (European Commission, 2020e).

At the same time, the EU Green Deal not only sets out the European Union's climate neutrality goals, but also sets a fundamentally new direction for the environmental policy and economic development strategies of the countries partici-

pating in the integration process (Tankovsky & Endrődi-Kovács, 2023). In the case of Ukraine, the green transition interpreted in the context of the Green Deal is not only a policy challenge but also an opportunity of geopolitical significance. The ecological and energy crisis caused by the Russian invasion in 2022 brings not only losses but also the possibility of a potential structural transformation that links the country's EU accession aspirations with sustainability goals.

3.1. Green transition in Ukraine

The structural conditions for a green transition in Ukraine are highly contradictory. The country possesses vast natural resource potential – particularly in agriculture, biomass, wind, and solar energy – yet it simultaneously struggles with major energy, technological, and institutional shortcomings. The destruction caused by the war has made the need for a new development paradigm more urgent. Decarbonization, the circular economy, biodiversity protection, and social justice must now be viewed not as competing priorities but as complementary goals (UNEP, 2023; World Bank, 2023).

The renewable energy sector offers the greatest potential. According to the Ukrainian Ministry of Energy, wind capacity could reach 30 GW annually, while solar power prospects are especially favourable in the south and centre of the country (Ministry of Energy of Ukraine, 2024). Before the war, renewables made up around 14–15% of the energy mix, but to reach 2030 targets, this share must rise to at least 30–35%, requiring an estimated USD 20–25 billion in investment. A 2023 analysis by the European Bank for Reconstruction and Development (EBRD) projects that Ukraine could generate up to 120 TWh of renewable energy in the decade following the war, a significant share of which could be exported, particularly in the form of hydrogen and green electricity.

The circular economy and resource efficiency are also central to the Green Deal. Prior to 2022, Ukraine had one of the lowest levels of resource efficiency in Europe: its material intensity per unit of GDP was more than double the EU average (OECD, 2022). War damage destroyed parts of the country's outdated industrial base, but this also created an opening for cleaner technologies. Reconstruction provides an opportunity to recycle secondary raw materials, reuse construction debris, establish industrial ecosystems, and promote product design focused on durability and repairability.

In agriculture, the green transition depends on agroecological methods, precision farming, and reduced fertiliser and pesticide use. A joint FAO–World Bank report (2022) found that 80% of Ukraine's arable land is devoted to low-biodiversity monocultures, a model unsustainable in the long term. Expanding regenerative farming practices such as crop rotation, mulching, and organic matter recycling would help mitigate soil degradation, strengthen rural economies, and increase carbon sequestration. Adapting the EU Common Agricultural Policy (CAP) framework and creating targeted support systems will be essential.

The social dimension is equally important. Energy and agricultural transformation will bring profound labour market changes, particularly in fossil fuel–dependent regions such as Donbas. Embedding the principle of a "just transition" into the Green Deal's implementation is critical for preserving social cohesion and public support (OECD, 2023). In 2024, the Ukrainian government launched its first retraining and mobility programs for mining communities and began promoting green jobs in renewable energy and environmental services.

Institutional frameworks are also taking shape. At the end of 2024, the Ministry of Environmental Protection adopted a Green Reconstruction Strategy that explicitly aligns with the EU Green Deal. The strategy rests on five pillars: (1) a carbon-free energy system, (2) resource-efficient industry, (3) ecosystem-based land use, (4) green mobility and transport, and (5) transparent, participatory governance (Ministry of Environmental Protection and Natural Resources of Ukraine, 2024).

Carbon pricing and the EU's Carbon Border Adjustment Mechanism (CBAM) represent additional challenges. Without a national emissions trading system, Ukraine risks a serious competitive disadvantage in exports to the EU, especially in steel, chemicals, and cement. A 2024 World Bank report estimates that 32% of Ukrainian exports are subject to CBAM, potentially adding up to €1.2 billion annually in costs if carbon pricing is not adopted (ICAP, 2023).

Finally, EU support instruments such as the Green Recovery for Ukraine Facility and the NDICI (Neighborhood, Development and International Cooperation Instrument) have earmarked substantial resources for financing the transition. By late 2024, the European Commission had allocated €7.8 billion for green reconstruction projects in Ukraine, targeting renewable energy, low-carbon transport, and industrial decarbonization (European Commission, 2024). Access to these funds, however, depends on regulatory convergence and improved transparency.

3.2. Adapting Ukrainian policy to meet the goals of the European Green Deal

Ukraine has gradually aligned its environmental policy guidelines since 2019 with international standards, particularly the European Union's Green Deal framework (European Commission, 2019a). In the field of energy transition, Ukraine developed several national plans aimed at increasing the share of renewable energy sources and phasing out coal-fired capacities. The Energy Strategy of Ukraine until 2035 set the objective of raising the share of renewables in the energy mix to 25% while reducing energy intensity and enhancing energy independence (Ministry of Energy of Ukraine, 2018). However, implementation remained uneven: the regulatory framework evolved slowly, investment risks were high, and support schemes for coal-based sectors persisted (IEA, 2021). Although investments in solar and wind power accelerated after 2020, grid integration and territorial coverage lagged behind EU benchmarks (OECD, 2022).

Several initiatives were launched to improve the sustainability of the agricultural sector. The Climate Smart Agriculture program (FAO & World Bank, 2022) and Green Agriculture initiatives sought to reduce environmental impacts of land use, promote crop rotation, cut fertiliser and water use, and expand agroecological practices. At the same time, the institutional system struggled to respond effectively to erosion, salinisation, and pollution. Knowledge-based agriculture and precision technologies were promoted, yet uptake remained limited as most farmers lacked the technical and financial capacity to modernise (OECD, 2023). Support systems also faced administrative inefficiencies and transparency concerns.

The gradual adaptation of the principles of the EU's Natura 2000 network and the rethinking of national nature conservation strategies played a key role in biodiversity protection. The 2021 Biodiversity Strategy and Action Plan included targets to expand protected areas, rehabilitate steppe and forest ecosystems, combat invasive species, and establish ecological monitoring systems (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021). However, these efforts were hampered by funding shortages, capacity constraints, and agricultural expansion pressures.

Regulatory reforms to reduce industrial environmental impact were also initiated in line with Green Deal objectives. The most significant was the introduction of the integrated environmental authorisation system, transposing the EU Industrial Emissions Directive (IED). Pilot programs started in 2019 and gradually expanded to larger industrial players. Despite the legal framework being in place, enforcement and sanctioning mechanisms remained weak, and only a few companies – mostly those linked to international investors – began adopting best available techniques (Energy Community, 2020).

Policies supporting the circular economy – such as waste management reform, resource efficiency, and sustainable consumption – were only in early stages until 2022. The 2021 Waste Management Act was the first comprehensive law to establish recycling, recovery, selective collection, and Extended Producer Responsibility (EPR) (Nikishyna et al., 2024). Yet actual infrastructure, including composting plants, recycling facilities, and logistics networks, remained underdeveloped, particularly in rural and eastern regions (Kaletnik et al., 2022). Social awareness and consumer patterns also did not sufficiently support circular economy models (Synchanskyy, 2025).

4. Towards a green future in Ukraine

The development of Ukraine's environmental policy institutional system has been closely linked to the country's political and administrative transformation since regaining independence in 1991. As part of the Soviet legacy, many former institutions continued to operate formally, while the redefinition of powers and responsibilities was long delayed. Although some organisational rationalisation began in the early 2000s, for example through the merger of state ecological supervision, forestry and water management authorities, these reforms did not result

in substantial capacity increases or efficiency improvements (Taranenko, 2024). The central governing body, the Ministry of Environmental Protection and Natural Resources, operated with chronic underfunding and weak political influence (Shevchenko, 2025). The executive and supervisory bodies under its authority, such as the institutions responsible for environmental impact assessments or air and water quality monitoring, lacked sufficient financial, technical, and human resources to enforce legal requirements.

As a result of decentralisation reforms, environmental policy became a multi-level and complex system, especially after 2014. Although the involvement of local actors and the strengthening of regional autonomy in principle created opportunities for the democratisation of environmental decision-making, the actual capacities, competencies, and coordination mechanisms were often lacking (Achasova and Achasov, 2024). Regional environmental agencies had no independent budgets or institutional autonomy, and were therefore often unable to implement environmental objectives at the local level. Regular reorganisations, sectoral fragmentation, and a lack of transparency further weakened the effectiveness of the environmental policy institutional system (Shevchenko, 2025).

The 2014 Association Agreement with the European Union was a significant milestone in Ukraine's efforts to harmonise its legislation, particularly in the areas of environmental protection and climate policy. The acquis adoption undertaken in the agreement covered more than twenty directives and regulations, ranging from air quality to waste management and water protection to industrial emissions (Sopilko et al., 2024). However, the harmonisation process was highly asymmetrical. Progress was made in some areas, such as waste management, while in other sectors, gaps in implementation and incomplete legal transposition remained. Although the legal framework for environmental impact assessment (EIA) and strategic environmental assessment (SEA) was established, their actual effectiveness remained limited due to weak public participation, inconsistent methodological guidance, and poor follow-up (Sopilko et al., 2024). The mechanism regulating industrial emissions still failed to comply with Directive 2010/75/EU, particularly regarding the use of best available techniques (BAT).

The instability of environmental regulation and the constant changes in the normative environment further undermined the predictability and legal certainty of regulation. In recent years, dozens of legislative amendments were adopted annually, often without strategic coherence, making it difficult for companies to adapt and reducing investor confidence (Kushnirenko and Gakhovych, 2021). However, achieving full legal harmonisation would require not only legal but also institutional and social reforms, coordination, and participation (Achasova and Achasov, 2024).

Despite these shortcomings, Ukraine has several structural advantages that offer opportunities to accelerate the green transition. In the field of renewable energy, particularly solar and biomass-based technologies, there has been significant progress in recent years. The rapid expansion of solar energy capacity between

2019 and 2021 was partly due to international support programs and the introduction of preferential green tariffs (Achasova and Achasov, 2024). The use of digital environmental management tools, such as electronic environmental reporting and data-driven regulation, could strengthen transparency and efficiency, although their impact is still limited at present (Taranenko, 2024).

Legal and technical alignment with the EU's carbon market mechanisms has also begun: in 2021, preparatory steps were taken to regulate carbon-intensive sectors and establish a national emissions trading system (Shevchenko, 2025). Access to international development resources – EU grants, multilateral aid programs, green bonds, and public-private partnership models – could open up new financing channels, provided that the integrity and management capacity of domestic implementation structures are strengthened (Kushnirenko and Gakhovych, 2021).

Ukraine's agricultural sector has particularly significant potential: the EU is one of the country's largest export markets, and the spread of sustainable agricultural technologies – such as agroecological systems, soil conservation practices, and reduced chemical use – would simultaneously improve export competitiveness and environmental conditions (FAO, 2021). In the energy sector, there is also realistic potential for developing green export capacities, particularly in solar and wind energy, which was to be facilitated by the planned connection to the EU electricity market before the war. The export of "green hydrogen" was also a strategic goal in several bilateral cooperation agreements, such as the negotiations with Germany (Energy Community, 2022).

International cooperation programs such as EU LIFE, Horizon, and Twinning have funded dozens of environmental projects in Ukraine aimed at local capacity building and knowledge transfer. However, many of these remained limited in scope or geography. Regional cross-border cooperation, such as water protection and nature conservation programs in the Carpathians, has also provided valuable experience for green integration (UNEP, 2022).

However, social participation and environmental awareness were already at a low level before the war. The involvement of civil society, local governments, and professional organisations lagged far behind Western European practices, especially in the preparation and implementation of environmental decisions. Environmental communication was weak, consultation mechanisms were not institutionalized, and the lack of information campaigns contributed to the social rejection of green measures. This was particularly true for policies that entailed short-term costs for the population or small businesses, such as energy price adjustments or the introduction of emission charges (UNDP, 2021).

Ukraine was therefore already on a relatively green path even before the Russian invasion, even though the country faced many serious problems and challenges. The war has obviously only made things worse, but the potential remains, given the commitment of Western countries to the country's reconstruction. However, green reconstruction requires a strategic approach that places the modernisation

of energy, transport, and industrial systems on a sustainable footing, while taking into account the need for ecosystem regeneration and the principles of social justice. A central element of the vision for the future must be the development of a national environmental and climate strategy that includes long-term emission reduction targets, adaptation priorities, and financing frameworks, in line with the EU Green Deal framework.

One of the most important tasks is to launch an ecological restoration program following the assessment of war damage, focusing on the rehabilitation of contaminated soil and water, the elimination of industrial pollution, and the restoration of ecosystem services. By prioritising resource-efficient technologies and supporting circular economic models, it would be possible to avoid a resurgence of traditional, polluting economic structures. Investments in green technologies, energy-efficient buildings, and low-emission transportation systems could generate multiplier effects on job creation, energy independence, and economic growth. Western partners can provide effective assistance in this regard.

From an institutional perspective, the post-war vision can only be successful if a strengthened, integrated, and corruption-free environmental management structure is put in place. The division of powers between state and local government actors needs to be clarified, and local decision-making capacities must be enhanced. A central green financing agency should be created to coordinate international aid and private investment, particularly in key areas such as energy, water management, and sustainable agriculture.

At the societal level, a sustainable future can be achieved if the population actively participates in environmental decisions and environmental awareness is strengthened. Environmental education, community energy and waste management programs, and the involvement of civil society would broaden the social base and increase the acceptance of green policies. The Ukraine of the future must not only be climate-neutral, but also socially inclusive, resilient, and technologically advanced.

Conclusions

The green reconstruction of Ukraine is an inherently complex, multidimensional process that must simultaneously address environmental, economic, and social crises of unprecedented scale while opening the way toward a more sustainable development path. The war has not only caused massive infrastructure losses but has also profoundly disrupted ecosystems, agriculture, water resources, and environmental security. Given the scale of damage, simple restoration is not enough: cross-sectoral, integrated approaches are essential, aligned with both historical environmental pressures and current climate policy goals.

Pre-war experiences show that Ukraine already faced deep-rooted sustainability challenges. CO_2 emission reductions were largely driven by economic decline rather than active decarbonization, while institutional weaknesses limited progress in EU harmonisation. Deficiencies in waste management, land and water

use, and renewable energy integration stemmed as much from financial and social constraints as from regulatory and technical gaps. Green reconstruction will therefore depend not only on mobilising new resources but on eliminating these systemic weaknesses.

The European Green Deal and Ukraine's integration process provide both direction and opportunity. They offer not just normative requirements but also structured support, conditional on coherent strategies, stronger institutions, and effective cross-sectoral coordination. Yet, genuine progress requires more than formal legal alignment: implementation, transparency, monitoring, and public participation must all improve. Ecosystem restoration, climate neutrality, and regenerative resource use together can lay the foundation for sustainable recovery.

Ukraine's green transition and post-war reconstruction must be seen as a single process. Future policy must integrate ecological, social, and economic dimensions as active tools of development, supported by long-term and transparent international assistance. Success will ultimately depend on whether Ukraine uses reconstruction not only to rebuild but to transform itself into a resilient, climate-neutral, and socially inclusive European state.

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