Environmental and Psychological Effects of Russian War in Ukraine

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Abstract
Russia invasion on Ukraine has extensive and unprecedented negative impacts on natural environment and human life. Since saving human lives and protecting nuclear establishments are a priority, the environmental destruction has even not been assessed fully. Russian war imposed on Ukraine has, no doubt, caused serious negative consequences on Ukrainian people and rest of the planet Earth. A massive damage to industrial and civil infrastructure has contaminated soil, water and food sources, which are hazardous not only for human but also for the ecosystem health. In addition to the devastating environmental effects, Ukrainian citizens are facing triple psychological problems: as human, as environmental repercussions, and as their national identity. Based on limited literature, this paper has compiled and reviewed the environmental consequences and psychological effects of Russian war in Ukraine in two interdependent parts: (a) Environmental Damages from Russian War in Ukraine, and (b) Psychological Injuries from Environmental Damage. The environmental damages covered include industries and chemical pollution, shelling-generated fires, pollution and waste from military vehicles, pollution by weapons and missiles, refugees-caused emissions, nuclear pollution, loss of water bodies, and damages to wildlife, biodiversity, ecosystems, to fuel and associated infrastructure, to mining operations, to ambient air quality, and to urban infrastructure. Based on narrative review of literature, this paper addresses the psychological effects of environmental pollution or damages caused by Russian war. Foremost psychological symptom of the war appears in the form of fear and uncertainty followed by direct threats to peoples’ lives. Various stressors contribute to anxiety, panic, mild or severe depression, insomnia, post-traumatic stress disorder (PTSD) and other stress-related disorders that severely affect public health.

Keywords
Russian war in Ukraine; Environmental destruction; Psychological effects
Introduction

Proxy war in Donetsk and Luhansk regions of Ukraine between 2014 and 2022 has affected environment and human psychology in all possible ways, as were documented in known cases of war in Afghanistan, Syria and Iraq. From 24 February 2022, the Russians led by Putin launched an unprovoked large-scale invasion of Ukraine rendering a humanitarian crisis of millions of people dying, getting injured or having to flee their homes (de Klerk et al., 2022). Massive military concentration using munitions and ammunitions has damaged or destroyed civilian infrastructure, energy installations, residential buildings, factories, and roads, while affecting adversely the humans’ mental health. Ongoing full-scale invasion by Russia has extensive and unprecedented negative impacts on natural environment and human life. Since the recent war erupted on 24 February 2022 till January 2023 (almost 10 months), death toll of civilians has reached nearly 7,000, while more than 11,000 are injured (Early, 2023). Moreover, nearly 10,000 soldiers have been killed and 30,000 injured, while more than 5,000 are missing, as a result of Russian war in Ukraine (Early, 2023).

Gardashuk (2022) classifies environmental impacts of war and hostilities in different ways: direct and indirect, short-term and long-term. She included:

- Destruction of landscapes, ecosystems, habitats, and species populations;
- Risks of technogenic catastrophes;
- Destruction, pollution, and withdrawal from the use of farmlands, violation of natural life support systems and natural services, which threatens the food safety of many people;
- Threats to human life and health due to degradation of ecosystems and technogenic catastrophes; restriction of access to natural resources, soil, water, and clean air, and risks of epidemics outbreaks.

The Ukrainian citizens have been facing triple psychological problems: as human, as environmental repercussions, and as their national identity. During this unprecedented war, Ukraine’s people are experiencing agonies of injustice and terror as their hard-earned democracy and freedom are being mercilessly threatened (Javanbakht, 2022). International Organization of Migration has assessed that over 15 million Ukrainians reported deterioration of their mental health since onset of the war on 24 February 2022 (IOM, 2022).

During one year of intensive war in Ukraine has not given chance to assess the environmental damages completely. Only a scarce little assessment is done by various organizations and scientists. An estimation of the total environmental damage inflicted by the war would be possible only after war is stopped. Preliminary assessments indicate that Ukraine's nature will take at least 15 years to recover. With the above introductory remarks, this paper is aimed at compiling and reviewing the environmental consequences and psychological effects of Russian war in Ukraine in two interdependent parts:

a) Environmental Damages from Russian War in Ukraine
b) Psychological Injuries from Environmental Damage

This paper is based on the review of the literature along with analysis of facts.
Methodology

The existing literature in contexts of environmental effects and psychological effects of environmental damages was the primary method to compose this paper. As explained by Templier and Paré (2015), six generic steps were undertaken in conducting the review process: 1) formulating the research questions and objectives, 2) searching the extant literature (chiefly from web sources), 3) screening and selecting for inclusion, 4) assessing the match or mismatch of findings, 5) extracting data, and 6) analysing and writing data and facts. The following main research questions that were formulated before the review was started:

a) What are different environmental damages caused by Russian war in Ukraine?
b) What are the extents of the environmental damages?
c) What are the secondary effects of direct environmental damages?
d) How are the human psychologies affected by environmental pollution and damages?
e) What may be the scenario of psychological impacts in the long-term?

It is a well-known fact that clearly articulated research questions are key ingredients that guide the entire review process; they underscore the type of information that is needed, inform the search for and selection of relevant literature, and guide or orient the subsequent analysis (Jesson, Matheson and Lacey, 2011). It has been tried to include majority of relevant published studies and news items to make the coverage of literature all-inclusive knowledge base. However, in psychological contexts, only selected studies published in reputed journals and available on PubMed platform were given priority. The literature was downloaded from web sources and was kept segregated. It was then screened and included or excluded keeping in view the research questions. Depending on the variables and headings set under the structure of this paper, the information and data was extracted from the screened articles by following the guidance of Cooper and Hedges (2009) and Okoli and Schabram (2010).

Narrative Review

Basically, composition of this paper, method of narrative review was applied. It is the “traditional” way of reviewing the extant literature and is the sources of interpreting qualitatively the prior knowledge (Sylvester, Tate and Johnstone, 2013). In fact, a narrative review is an attempt to summarize or synthesize what is written on a particular topic (Davies, 2000; Green, Johnson and Adams, 2006). As such, it selectively picks up certain studies and ignores others in order to make a point. It is the limitation of such a review. The review is presented in logical sequence with lucid presentation of the text.

Part-A: Environmental Impacts of Russian War in Ukraine

According to Rawtani et al. (2022), Russian war imposed on Ukraine has caused serious negative consequences on local people and rest of the planet Earth. It is observed that massive damage to industrial and civil infrastructure has contaminated soil, water and food sources, which are hazardous not only for human but also for the ecosystem health. The bombing and missile explosion create toxic substances, such
as lead, mercury, depleted uranium, and many more. They are released into air, water, and soils. When entered human bodies, the explosives like TNT (Trinitrotoluene), DNT (Dermonecrotic toxin), and RDX (cyclonite or cyclotrimethylenetrinitramine) cause malfunction of all organs and systems. Apparently, attacks in heavily industrialised areas are causing technological disaster, such as spills of tailings and fuel, poisoning a vast area in Ukraine. Destruction of buildings releases carcinogenic dust, impacting human health and plant life. Resulting spread of heavy metals and chemicals reaches ultimately to underground waters, poisoning water sources, killing all life in rivers and water bodies. Likewise, military emissions of CO$_2$ are recorded to be millions tonnes undermining the goals of Paris Agreement. Along with the electricity interruptions, there is a rampant water shortage and deterioration of sanitary conditions. Different reports indicate that destruction of civil infrastructure has already left more than 4 million people without access to pure drinking water (English, 2022). Russian war in Ukraine posed enormous threats of nuclear accidents. The war has adversely affected the air quality due to unprecedented bombarding, missile attacks and ground ammunitions. The Russian occupation of Ukrainian nuclear sites caused leakage of radiation in north and southern Ukraine. Rawtani et al. (2022) have reiterated that physical, chemical and biological characteristics of soil have changed negatively as a result of excessive shelling and explosions; consequently, agriculture is severely affected. This war has caused large-scale deforestation and wildfires, couples with biodiversity loss (Rawtani et al., 2022). Gardashuk (2022) articulated that the war causes suffrage to all living beings and their habitats. The ecosystems are “silent victims” of the war. According to her, military actions heavily disrupt the normal functioning of ecosystem services, like climate support systems, soil fertility, purification of water and air, pollination, etc. (Gardashuk, 2022), since the military actions cause high level of emission of harmful substances from the military machines and other weapons, triggering technogenic pollution by targeting the industrial objects. She reiterates, “war violates basic principles of environmental justice and exacerbates injustice in all its forms and manifestations”.

**Bombing of Industries and Chemical Pollution**

Data of State Register of Potentially Dangerous Objects of Ukraine declares that Ukraine has over 23,000 facilities, including 2,987 warehouses that store highly toxic pesticides (Bazhenova, 2022), with majority of them in Donetsk, Dnipropetrovsk, Zaporizhzhia, Kharkiv and Lviv regions. Some of such facilities are located in the combat zone. Within initial 3 months of war, damages to the infrastructure of Ukraine reached USD 97.4 billion. At least 216 plants, factories, and enterprises suffered in 3 months of war (Bazhenova, 2022). More than 10 m tonnes of toxic waste and tailings are said to be stored in this region (CEOBS, 2018). Rockets and explosions result in leakages from various facilities of hazardous materials that poison air, water, and soils (Morber, 2022). It was reported that on 25 February, chemical reagents were disposed (BBC, 2022; Suspilne, 2022) followed by an attack on Lysychansk refinery that ignited 50,000 tonnes of oil sludge, on two reservoirs with 20,000 tonnes of petroleum, and on a sulphur store (Interfax, 2022). Ever since the war broke, there is large number of attacks on Ukrainian infrastructure and industries. For example, on 21 March, ammonia reservoirs at Sumykhimprom were hit (Kizilov, 2022), followed by a leakage covering an area of 2.5 km in radius. On 5 and 9 April...
2022, nitric acid tanks were blown in Rubizhne (Izvestiya, 2022). There is an endless series of attacks and accidents; some are also mentioned in table 1.

According to UNEP (2022), between 2014 and 2017, potentially hazardous coke and chemical plants, power plants and other chemical industries were affected due to armed conflict between Ukraine and Russia. Damage was reported in Avdiivka Coke and Chemicals Plant, Toretsk Phenol Plant, the Donetsk State-Owned Chemicals Plant and the Stakhanov Ferroalloy Plant in 2016-2017 (UNEP, 2022). Fire at the Avdiivka Coke and Chemicals Plant in 2015 resulted in the emission of coke gas with high concentrations of benzene, toluene, naphthalene, hydrogen sulphide, mercaptan, hydrocyanic acid and ammonia (OSCE, 2017). Today, it is hard to assess the toxic effects of the gaseous air pollutants emitted from burning industries. The hazardous toxic chemicals in the atmosphere last from several hours to several days, and subsequent fallout onto soil and into water can last longer than several years (OPCW, 2022).

Table 1: State Environmental Inspectorate of Ukraine (2022a) documented in June 2022 seven confirmed incidents of release of toxic industrial chemicals caused by military activities (UNEP, 2022)

<table>
<thead>
<tr>
<th>Industrial Site</th>
<th>Location</th>
<th>Date</th>
<th>Description of the Incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke Plant</td>
<td>Avdiivka</td>
<td>13 March 2022</td>
<td>Large fire caused by shelling.</td>
</tr>
<tr>
<td>Sumy Khimprom</td>
<td>Sumy</td>
<td>21 March 2022</td>
<td>Release of ammonia; the gas cloud covered an area of 2.5 km².</td>
</tr>
<tr>
<td>SOE Khimprom</td>
<td>Chernihiv</td>
<td>23 March 2022</td>
<td>Depressurizing of a tank with liquid ammonia (12 tons), followed by a fire in the working premises.</td>
</tr>
<tr>
<td>Scientific–Industrial Enterprise Zorya</td>
<td>Rubezhne, Luhansk oblast</td>
<td>5 April 2022</td>
<td>Release of the 80 tons of nitric acid caused by the hit of storing tank. The radius of the affected area reached 3.5 km.</td>
</tr>
<tr>
<td>Severodonetsk Azot</td>
<td>Severodonetsk</td>
<td>5 May 2022</td>
<td>Heavy shelling in the one of the largest ammonia producers in Ukraine.</td>
</tr>
<tr>
<td>Azovstal</td>
<td>Mariupol</td>
<td>29 May 2022</td>
<td>Release of liquid ammonia due to the damage of pumping station. The radius of the affected area reached 2.5 km.</td>
</tr>
<tr>
<td>Ammonium pipeline Tolyatti – Odessa</td>
<td>Nearby town of Bakhmut in Donetsk oblast</td>
<td>30 May 2022</td>
<td>Release of technical (low pressure) ammonium from a non-operational bypass pipe. At least six communities were under threat of chemical pollution.</td>
</tr>
</tbody>
</table>

*Source: Adapted from UNEP (2022)*

Scientists have explained that the explosions, destructed armour and vehicles, burning and spilled fuel actually pollute air, water and soils indiscriminately. It is evident that explosion of every bomb releases pollutants, such as heavy metals (McCarthy, 2022), formaldehydes, nitrous oxide, hydrogen cyanide, and toxic organic compounds (Omelchuk and Sadohurska, 2022). These pollutants are spread by winds and underground waters, that’s why the hazardous ecological impact of war will affect not only Ukraine but also Russia and Europe (Kotarska and Young, 2022). According to Omelchuk and Sadohurska (2022), explosives release chemical compounds that are
oxidized on air and may cause acidic rains causing burn of vegetation and respiratory organs of mammals, including humans.

As highlighted by Zalakeviciute et al. (2022), the resulting pollution has short-lived impact as well as persisting impacts. They articulate, “the toxic emissions, originating from military actions and destruction, will go on contaminating not only the atmosphere, but also water and soil, through wet and dry deposition. The pollution-related health problems will affect not only the local population, but also the combating armies and the surrounding territories.” Massive attacks of Russian rockets cause large-scale fires at targeted critical infrastructure, especially oil depots, storage terminals, and chemical plants. This destruction causes serious damage to ecosystems and leads to significant environmental pollution that poison the air, land, rivers, groundwater and surface water. Assessment of the loss and damage has been continuing preliminarily, although the final assessment can be possible years after the ceasefire.

**Damage to Fuel and Associated Infrastructure**

Fuel storage facilities are often targeted by Russian missile and drone attacks to undermine the ability to sustain military operations by Ukraine (de Klerk et al., 2022). In April 2022, missiles demolished (Ukrainskaya Pravda, 2022) the Kremenchug refinery, which has a capacity of 3 million tons of oil per annum, in Poltava oblast. Similarly, Shebelinka gas processing plant in Kharkiv oblast was forced to stop its operations (Reuters, 2022) in February 2022. Andriy Herus, a parliamentarian and the Head of the Parliamentary (Verkhovna Rada) Committee on Fuel and Energy, stated during a briefing (Interfax Ukraine, 2022a) in the Crisis Media Centre on 5 May 2022 that “about 15 different oil depots in Ukraine were destroyed or damaged as a result of missile strikes, which means that significant fuel reserves were destroyed, the storage of oil products was also complicated”. Simultaneously, the State Environmental Inspectorate of Ukraine (2022b) reported more than 20 cases of attacks on reservoirs with petrol, diesel, liquefied petroleum gas and mazut (fuel oil).

**Effect on Mining Operations**

Ukraine is known for heavy industry associated with mining in eastern regions. There are nearly 150 coal mines in Ukraine. Between 2014 and 2017, armed conflicts negatively impacted mining operations (OSCE, 2017) with destruction of equipment and interruptions of electrical supply. Failure of electric supply in mining resulted in flooding; and some coal mines were completely submerged, causing risks of groundwater and surface water pollution (Ministry of Environmental Protection and Natural Resources of Ukraine, 2017). UNEP (2022) highlighted that old mines used for waste storage were also affected in Donetsk and Luhansk regions. The Ministry further warned that major mine flooding reaching surrounding areas endangered nearby buildings and other critical infrastructure through contaminated groundwater. As a result of excessive shelling, the tailing pond of the Phenol Plant Coke and Chemicals Enterprise (Donetsk oblast) containing 400,000 cubic meters of waste, had failed and caused water pollution of drinking water sources coming from Kryvyi Torets and Siverskyi Donets rivers (OSCE, 2017).
According to Marx et al. (2022), coal mines in eastern Ukraine have deteriorated since active and intensive hostilities have made it difficult to continue. Groundwater pollution across Donbas region is reported prominently. Evidently, when a mine is flooded, radionuclides and toxic substances contaminate underground waters, poisoning water sources of local residential areas (Renáta, 2022). European Commission specialists registered at least 35 abandoned coal mines in Donbass region (European Commission, 2022), and waters of Komyshuvakha river turned orange in 2021 due to a leakage from the abandoned 'Zolotoe' mine.

Worsening of Ambient Air Quality

Zalakeviciute et al. (2022) analysed satellite images of nitrogen dioxide (NO$_2$), carbon monoxide (CO), ozone (O$_3$), sulphur dioxide (SO$_2$) and PM$_{2.5}$ land monitoring data for Kyiv. They found that NO$_2$ and PM$_{2.5}$ are released the most during war activities. According to the authors, drastic increases in pollution (especially PM$_{2.5}$) from bombing and structural fires raise additional health concerns. Zalakeviciute et al. (2022) reported O$_3$ (2.45% for Ukraine and 3.38% for Kyiv) and SO$_2$ (38.06% for Ukraine and 10% for Kyiv) levels higher during the first two weeks of the war compared to pre-war conditions (before 24 February 2022). The PM$_{2.5}$ data presented by these scientists demonstrated the most drastic increase in its concentrations nationally. The same authors have highlighted Kyiv and Donetsk recording a prolonged exposure to smoke particles pollution arising from the bomb/missile explosions and destruction of military/civil objects.

In the COP27 meeting of UN Climate Summit held in Egypt, Ukrainian official delegation reported that “Russia's invasion of Ukraine has caused a large amount of warming gases released into the atmosphere, equivalent of adding nearly 16 million cars to the UK's roads for two years”. According to BBC, war has pumped directly into atmosphere the emission of 33 million tons of greenhouse gases that would warm the Earth's atmosphere (Rannard, 2022). Ruslan Strilets, Ukraine's Environmental Protection Minister is quoted claiming in UN Climate Summit 2022 that “Russia has turned our natural reserves into a military base. Russia is doing everything to shorten our and your horizons. Because of the war, we will have to do even more to overcome the climate crisis” (Rannard, 2022). Minister also claimed that rebuilding Ukraine will cause significantly more emissions, up to 49 million tons of carbon dioxide. Since the start of the war, Ukraine claims to have gathered evidence of 2,000 environmental crimes costing 37 million Euros, including destruction of forests, release of toxic gases, and damage to water facilities (Rannard, 2022).

Damage from Shelling-Generated Fires

Ukraine Nature Conservation Group (UNCG), a non-profit coalition of the country’s scientists and activists, claimed that 37,000 fires occurred in the first 4 months of the invasion affecting severely a quarter-million acres of forests and other natural ecosystems (Pearce, 2022). These fires have been caused by shelling, bombing and mine-laying operations. No accurate data is available about the small and medium sized fires. The assessments are available of the fires that had more than 1 hectare

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1 PM$_{2.5}$ refers to tiny particles or droplets in the air that are two and one half microns or less in width.
size. Such assessments are conducted by US-based Fire Information for Resource Management System (FIRMS)\(^2\) and the European Forest Fire Information System (EFFIS)\(^3\) by dividing the territory of Ukraine into 3 zones (see Figure 1), namely:

Zone 1: It covers 66.5% of the territory of Ukraine, where no ground warfare is operational;
Zone 2: This is zone of active warfare (ground warfare were/are conducted for more than 24 hours\(^4\)), covering 19.5% of the territory of Ukraine; and
Zone 3: It is temporarily occupied territory (14.0% of the territory of Ukraine), where ground warfare was/is conducted for not more than 24 hours or did not take place at all.

![Figure 1: Frontlines and Zone 1 (blue), Zone 2 (yellow) and Zone 3 (red) (adapted from de Klerk et al. (2022))](image)

Between 24 February 2022 to 24 September 2022 (214 days), the fires were assessed by EFFIS and are illustrated in table 2. EFFIS created data from satellite imageries and compared it with the data for the period 24 February 2021 to 24 September 2021.

Based on the assessment of fires, the CO\(_2\) emissions are calculated by de Klerk et al. (2022), which are illustrated in table 3.

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\(^2\) [https://firms.modaps.eosdis.nasa.gov](https://firms.modaps.eosdis.nasa.gov)

\(^3\) [https://effis.jrc.ec.europa.eu](https://effis.jrc.ec.europa.eu)

\(^4\) [https://liveuamap.com/uk](https://liveuamap.com/uk)
Table 2: Fires in Ukraine for 214 days of the war (with an area of more than 1 ha)

<table>
<thead>
<tr>
<th>Distribution of fires</th>
<th>Number of fires</th>
<th>Total fire area, ha</th>
<th>Area of forest fires, ha</th>
<th>Area of farm fires, ha</th>
<th>Area of other natural component fires, ha</th>
<th>Area of fires in built-up areas, ha</th>
<th>Area of other fires, ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>2,066</td>
<td>122,693</td>
<td>7,618</td>
<td>94,656</td>
<td>19,342</td>
<td>471</td>
<td>604</td>
</tr>
<tr>
<td>Zone 2</td>
<td>3,724</td>
<td>315,046</td>
<td>47,443</td>
<td>234,002</td>
<td>29,302</td>
<td>2,747</td>
<td>1,546</td>
</tr>
<tr>
<td>Zone 3</td>
<td>425</td>
<td>48,423</td>
<td>2,164</td>
<td>43,057</td>
<td>2,965</td>
<td>146</td>
<td>92</td>
</tr>
<tr>
<td>Total</td>
<td>6,215</td>
<td>486,162</td>
<td>57,225</td>
<td>371,715</td>
<td>51,609</td>
<td>3,364</td>
<td>2,242</td>
</tr>
</tbody>
</table>

Source: Adapted from de Klerk et al. (2022)

Table 3: Greenhouse gas emissions for 214 days of the war (in thousand tons CO$_2$e)

<table>
<thead>
<tr>
<th>Distribution of fires</th>
<th>Emissions from forest fires</th>
<th>Emissions from farm fires</th>
<th>Emissions from natural component fires</th>
<th>Emissions from fires in built-up areas</th>
<th>Total emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>2,202</td>
<td>1,068</td>
<td>137</td>
<td>373</td>
<td>3,780</td>
</tr>
<tr>
<td>Zone 2</td>
<td>13,711</td>
<td>2,640</td>
<td>208</td>
<td>2,177</td>
<td>18,736</td>
</tr>
<tr>
<td>Zone 3</td>
<td>625</td>
<td>486</td>
<td>21</td>
<td>116</td>
<td>1,248</td>
</tr>
<tr>
<td>Total</td>
<td>16,538</td>
<td>4,194</td>
<td>366</td>
<td>2,666</td>
<td>23,764</td>
</tr>
</tbody>
</table>

Source: Adapted from de Klerk et al. (2022)

Above analysis by de Klerk et al. (2022) for 7 months of Russian war imposed on Ukraine reveals that total number of fires having an area of >1 ha increased 122 times compared to the same period in 2021, while its total area has increased 38 times. It means, 79% of greenhouse gas emissions from the war-related fires accounted for 20% of the territory (Zone 2), and the density of greenhouse gas emissions from fires in Zone 2 was found 17 times higher than in Zone 1 (de Klerk et al., 2022).

**Pollution and Waste from Military Vehicles**

According to Solomon et al. (2018), “heavy military vehicles consume a lot of fuel and produce many hundreds of thousands of tons of carbon monoxide, nitrogen oxides, hydrocarbons and sulphur dioxide. de Klerk et al. (2022) have analysed that large volume of fuel is required during the mobilisation of forces, relocations, and operational movements. Usually, old tanks and armoured fighting vehicle (AFV’s) lack auxiliary power units to run for recharging its batteries, so engines need to run periodically to recharge the batteries. In addition, fuel is also used by civilian vehicles involved in war-related activities e.g., emergency services, medical vehicles, movements related to evacuation, rebuilding supply chains, the use of tractors to recover abandoned and damaged vehicles, etc. (de Klerk et al., 2022). Extended consumption of fossil fuels leads to significant emissions of greenhouse gases (GHGs) and climate change impacts. From 24 February 2022, the consumption of fuel for military purposes in Ukraine has increased significantly, approximately threefold.
Important to note here is that Russia’s significantly higher consumption of fuel (1.5 million tonnes compared to 0.5 million tonnes) is used for war against Ukraine. Gross fuel consumption by Russian war in Ukraine is estimated at 2 million tonnes with total GHG emissions of 6.37 million tonnes CO₂e (de Klerk et al., 2022).

In context of Ukraine, as of now, exact data is unavailable on debris generated by the destruction or abandonment and subsequent degradation of military vehicles. The debris inevitably causes environmental pollution and associated health risks. Specific components of vehicles (e.g. vehicle batteries) contain lead or other toxic compounds that are harmful to biota and humans (Lawrence et al., 2015). Massive debris of fuel deposits, grease, paint, batteries, tyres and cables result in harm to flora and fauna (Clark and Jorgenson, 2012). In addition to the vehicles, military aircrafts result in massive air pollution with high concentration of ammonium perchlorate, polyvinyl chloride, lead stearate, polybutadiene and polyethylene (Edeko, 2011). The warships are big source of contamination of sea water. Along with the emissions and pollution, waste from ships can also contain the pollutants and metals ending up in the brackish water. Destroyed naval ships result in oil contamination and, thus, pose a heavy risk to marine ecosystems (Lawrence et al., 2015).

Pollution by Weapons and Missiles

According to an estimate by de Klerk et al. (2022), artillery use is 0.9 million rounds per month (30,000 rounds per day) or 5.4 million per 6 months of the war for Russia and additionally 0.2 million rounds per month (7,500 rounds per day) or 1.35 million per 6 months of the war for Ukraine. de Klerk et al. (2022) further quoted the Royal United Services Institute for Defence and Security Studies report claiming that Russia was firing approximately 20,000 of 152-mm artillery shells per day compared to Ukraine’s 6,000. Another analyst claimed on social media that the firing rate was 1-1.5 million rounds per month (30,000 – 50,000 per day) from May 2022 onwards. Representatives of the Ministry of Defence of Ukraine reported the use of 40,000-60,000 rounds per day by Russia (de Klerk et al., 2022) during the period of intense fighting. Other estimates claim that during 6 months of the war, Russia alone could have fired 7 million of artillery rounds, excluding the losses occurred due to the destruction of warehouses. These above estimates are again illustrative, as there is no accurate data available. To understand the quantum of artilleries used, it is essential to assume weight of an artillery round together with its container, which is 80 kg. The total weight of artillery rounds that need to be transported to the battle field is 432,000 tonnes for Russia and 108,000 tonnes for Ukraine (540,000 tonnes in total) (de Klerk et al., 2022).

How much is the emission load from the artillery fires and smokes? It is expected to be approximately 1 million tonnes CO₂e. In their report, de Klerk et al. (2022) reported the emissions from the use of artillery munitions as follows:

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5 Ukraine at War Paving the Road from Survival to Victory, https://static.rusi.org/special-report-202207-ukraine-final-web_0.pdf
6 https://twitter.com/Volodymyr_D_/status/1560350883929620481
8 https://theins.ru/politika/254514
• 918,000 tonnes CO₂e from the manufacture of munitions (steel casing and explosives);
• 19,778 tonnes CO₂e due to emissions at the point of firing and at the point of impact;
• 1,283 tonnes CO₂e from detonation at the point of impact; and
• 18,131 tonnes CO₂e from the transportation of munitions.

The following estimate reveals that overall emissions from the use of munitions and explosives would reach 1.2 million tonnes CO₂e. It is because an additional 30% of the emissions should be added to above figures attributing to the use of other explosives and munitions, e.g. small calibre rounds, medium and heavy mortar projectiles, land mines, hand and drone grenades, munitions for tank guns, artillery rockets and air missiles, etc. (including various munitions exploded during the destruction of armour and vehicles). Break of the emissions from different sources is given in the table 4.

Table 4: Total GHG emissions from the warfare (adapted from de Klerk et al., 2022)

<table>
<thead>
<tr>
<th>Emission types and sources</th>
<th>thousand ton CO₂e</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions from fuel consumption by the Russian Army</td>
<td>4,779</td>
<td></td>
</tr>
<tr>
<td>Emissions from fuel consumption by the Ukrainian Army</td>
<td>1,593</td>
<td></td>
</tr>
<tr>
<td>Emissions from Air Force</td>
<td>1,036</td>
<td></td>
</tr>
<tr>
<td>Pre-invasion force accumulation</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td>Invasion and Russian troops’ operational movement</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Delivery of artillery munitions from temporary warehouses to the battlefield</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal fuel consumption</strong></td>
<td><strong>7,636</strong></td>
<td><strong>86.2</strong></td>
</tr>
<tr>
<td>Emissions from the use of artillery munitions</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Emissions from the manufacture of artillery munitions</td>
<td>918,000</td>
<td></td>
</tr>
<tr>
<td>Emissions from the use of other munitions</td>
<td>5,933</td>
<td></td>
</tr>
<tr>
<td>Emissions from the manufacture of other munitions</td>
<td>275</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal ammunitions</strong></td>
<td><strong>1,219</strong></td>
<td><strong>13.8</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8,855</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The ammunition used in war is made 95-97% of lead, zinc, nickel, barium, manganese, copper, antimony, depleted uranium, etc. Undoubtedly, lead is toxic and highly penetrable as it enters human body not only with air or water, but also through skin and hair. Prolonged exposure to lead leads to kidney failure with effects on nervous system. Serious illnesses include encephalopathy, anaemia, loss of coordination and memory. Numerous neurotoxic effects are observed in animals too. In the Russian war in Ukraine, TNT, DNT, and RDX have been used recklessly, causing acute intoxication with long-term mutagenic effects in populations. Because TNT is easily absorbed through skin and mucous membranes, its carcinogenic effects can induce alopecia, anaemia, liver failure, cataract, etc. (Zaborona, 2022). Hexogen poisoning causes nausea and anaemia, and prolonged exposure leads to kidney and liver failure. Likewise, DNT is equally toxic, and, in high doses, it can disrupt
cardiovascular system apart from oncological provocation. Various sources indicate that toxic clouds rose after the massive explosions and fires covered residential towns and villages, resulting to a severe damage to health of the locals seen already and may be seen in near future (Darbyshire, 2022; Weir, 2022; Wesolowsky, 2017). In Ukraine, the toxic damages caused by hostilities are even more hazardous (Dathan, 2020).

**Refugees and GHG Emissions**

According to UNHCR website, as on 31 January 2023, there were 8,046,560 refugees from Ukraine recorded across Europe, and 4,823,326 refugees from Ukraine registered for Temporary Protection or similar national protection schemes in Europe. Likewise, since 24 February 2022 till 31 January 2023, 18,159,214 Ukrainians crossed the borders into neighbouring countries (Bulgaria, Czech Republic, Romania, Slovakia, Moldova, Hungary and Poland). As many as 5,352,000 people were estimated to be internally displaced in Ukraine as on 23 January 2023, according to Internal Displacement Monitoring Centre (IDMC) quoting IOM (2023).

Forced migration of affected people leaves serious footprints. Thus, forced mass relocation of people overloads infrastructure of host regions. It is observed that refugee camps accumulate waste (Cottrell and Dupuy, 2021) and have almost no recycling facilities. One other report by de Klerk et al. (2022) projected the emission of GHGs by Ukrainian refugees (as on 22 October 2022) in various European countries and the internally displaced people (IDPs). The projections are illustration in table 5.

Table 5: GHG Emissions by Refugees and IDPs (Calculations of emissions by de Klerk et al., 2022, p.28)

<table>
<thead>
<tr>
<th>Category of People</th>
<th>Thousand ton CO2 Emitted</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal displacements</td>
<td>50</td>
<td>3.6</td>
</tr>
<tr>
<td>International refugees</td>
<td>539</td>
<td>38.6</td>
</tr>
<tr>
<td>Transports returning empty</td>
<td>539</td>
<td>38.6</td>
</tr>
<tr>
<td>Refugees returning</td>
<td>215</td>
<td>15.4</td>
</tr>
<tr>
<td>Refugees visiting</td>
<td>54</td>
<td>3.7</td>
</tr>
<tr>
<td>Total</td>
<td>1,397</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Source: Adapted from de Klerk et al., (2022)*

**Nuclear Pollution from Russians War in Ukraine**

Noticeably, Ukraine is Europe’s second largest producer of nuclear power. In Ukraine, almost 50% of electricity comes from nuclear power plants. Commonly, the nuclear plants are vulnerable to missile, rocket or mortar hits (Brown and Solomon, 2022; Castelvecchi, 2022; Cavanagh, 2022). Reports revealed that, in February 2022, the Russia took control of the Chernobyl nuclear power plant and other nuclear facilities

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9 https://data.unhcr.org/en/situations/ukraine, assessed 08 February 2022
10 https://www.internal-displacement.org/countries/ukraine#internal-displacement

Another explosion was reported on 27 February 2022 by a rocket attack in the Kyiv suburb of Pirogovo. That explosion hit the location of the Central Production Site of the Radon Association doing a disposal of radioactive waste (Ministry of Environmental Protection and Natural Resources of Ukraine, 2022; State Nuclear Regulatory Inspectorate of Ukraine, 2022). Kharkiv Institute of Physics and Technology located with the Neutron Source nuclear reactor with 37 nuclear fuel assemblies was attacked on 6 March 2022 (State Nuclear Regulatory Inspectorate of Ukraine, 2022). As Gardashuk (2022) states, “invaders brutally violate all rules of war, international conventions and treaties, resorting to terror, thus threatening ecology and human lives apart from global safety. Russian forces deliberately occupy and target nuclear power and research facilities (including Chernobyl and Zaporizhzhya nuclear plants, and Kharkiv Institute of Physics and Technology), thus resorting to nuclear blackmailing and putting human lives and environmental safety at stake.”

According to de Klerk et al. (2022), outage of the Zaporizhzhia Nuclear Power Plant supplying 25% of electricity demand will lead to more coal-fired power production. It would add to already exorbitant levels of pollution. In the operation of power plants, more attention is given to nuclear reactors, any damage to the spent nuclear fuel or storages of spent nuclear rods can be extremely devastating (Jacobo, 2022; SMC, 2022). According to the International Atomic Energy Agency (IAEA), two Russian missiles already hit nuclear waste ponds in Ukraine (Conover, 2022; Mathiesen, Guillot and Zimmermann, 2022). Mega accident was escaped by Ukrainian army. According to experts, the spent nuclear fuel may release 20 times the fatal dose of radiation in an hour (Stapczynski and Oda, 2022).

Radioactive pollution from nuclear reactors has been world known from Chernobyl of Ukraine. It is known fact that particles of depleted uranium are 100 times smaller than leukocytes and easily pass the blood-brain barriers. These radioactive high energy particles directly reach the olfactory nerves and disrupt cognitive and thinking processes. Moreover, radioactive antimony causes inflammation of cardiovascular, respiratory and digestive systems. Similarly, radioactive nickel damages the immune system (Omelchuk and Sadohurska, 2022).

**Damage of Wildlife, Biodiversity, Ecosystems**

Russian invasions on Ukraine have severely destroyed the steppe grasslands existing only 3% in southern and eastern Ukraine. Out of many rare and endangered plant

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species in steppes, about 20 steppe species are believed to have disappeared due to the war (Pearce, 2022). Largely, these species are endemic to the Black Sea peninsula of Crimea, believed to be “the largest centre of endemism on the territory of Ukraine,” having 44 plant species that are found nowhere else on Earth (Pearce, 2022). Moreover, Ukraine’s protected areas are claimed to have been heavily suffered from Russian war waged in Ukraine. The Ukrainian Parliament Commissioner for Human Rights, Lyudmila Denisova, emphasized that there are about a third of the nature reserve fund of Ukraine under threat of destruction. Luhansk Nature Reserve, Black Sea Biosphere Reserve, Askania-Nova Biosphere Reserve, National Nature Parks “Azov-Sivasky” and “Dzharihgilgatyshky”, arboretum “Trostenets”, and others have seriously damaged. The Kherson Hydrobiological Station has been severely damaged (Gardashuk, 2022). The Ministry of Environmental Protection and Natural Resources of Ukraine (2017) reported 60 protected sites being affected in eastern Ukraine. The war affected heavily the biological diversity and declining rare animal and bird species.

Early (2023) has reported that more than 600,000 hectares of wetland are under threat from this war. Of such watershed, 16 ecosystems are designated as Ramsar sites for the international importance of its unique biodiversity and birdlife. War has affected all natural corridors of national importance except the Crimean and Carpathian ones, causing significant damage to landscapes and nature (UNEP, 2022). According to official estimates, 20% of all nature conservation areas of Ukraine are severely affected by the Russian attacks. About 1 million hectares area of protected areas has been affected and 812 specific sites in different protected areas are damaged. As the Nature Reserve Fund of Ukraine (2022) reported, nearly 160 territories of the Emerald Network\(^\text{15}\) having an area of 2.9 million hectares, 14 Ramsar sites\(^\text{16}\) expanding over an area of 400,000 hectares, and 4 biosphere reserves\(^\text{17}\) are under threat. Reports spell that Russians had occupied 8 nature reserves and 10 national parks. Ukrainian army liberated the Kamianska Sich National Park in the Kherson region in November 2022 after 8 months of occupation by Russian forces. More than 90 species of rare animals in grassland ecosystem have suffered. A satellite data shows that 635 hectares area containing rare plant species, such as hairy feather grass and Ukrainian feather grass, is destroyed by fire as a consequence of shelling by Russians (Early, 2023).

Some examples of impact of war on nature are illustrated hereunder:

- Images from the European Space Agency’s Sentinel 2 showed on 18 March 2022 an active fire in primeval forest of nature reserve in Svyate (44 hectare protected area in the southern part of Chernihiv city) (NASA, 2022).
- In the Luhansk region, fire was caused 9 May 2022 by heavy shelling resulting into forest burning in Kudryashivka, Kremnaya, Chervona Dibrova and between Purdivka and Metelkin. This fire advanced in the direction of Yampil and approximately 15,000 hectares were reported burnt (State Environmental Inspectorate of Ukraine, 2022b).
- On 10 May 2022, Heroyske, Chulakivske, Ivanovske, Kardashinske forests, Holoprystansky forestry enterprise and the Black Sea Biosphere Reserve in the Kherson oblast were reported burning (State Environmental Inspectorate of Ukraine, 2022b).

\(^{15}\) https://uncg.org.ua/en/
\(^{16}\) https://www.ramsar.org/news/ukraine-designates-eleven-ramsar-sites
\(^{17}\) https://en.wikipedia.org/wiki/Biosphere_reserves_of_Ukraine
of Ukraine, 2022b). Despite the attempts of extinguishing fire and sweeping the areas to prevent fire spread, nearly 6,000 hectares were destroyed (Interfax Ukraine, 2022b).

- According to the Ukrainian Ombudsman, Liudmila Denisova, fires (Ukrinform, 2022a) in the forests of Kinburn Spit Reserve were observed. It was reported that the entire vegetation in that forest was under threat of destruction. It is the largest field of wild red orchids in Europe (more than 60 hectares), perennial trees, pink lakes and animals.

Another classical case of destruction of natural ecosystems by war is the case of Snake Island in the Black Sea, known locally as Zmiinyi Island. Ukraine retook the island in June 2022 after 4 months of Russian occupation. The reoccupation of the island by Ukraine left the island burned and littered with toxic munitions. Recently, the island was recorded having about 200 species of flowering plants and inhabited by more than 200 species of birds. According to Pearce (2022), everything is reported to have been burned in the island. “Most of the exclusion zone was damaged by the invasion and may be contaminated with unexploded ordnance and mines,” director of the Chernomorskiy Biosphere Reserve, Oleksandr Galushchenko, lamented. He emphasized that wolves, deer, brown bears, lynx, elk, and bison are at particular at risk (Pearce, 2022). According to the World Wildlife Fund (WWF), more than 280,000 hectares of forests are destroyed or felled by army operations (VoA, 2022). It amounts to a damage of more than $37 billion, according to the Audit Chamber, a non-governmental group (VoA, 2022).

Not only the wild animals, but farm animals, especially cows, were also targeted by Russian forces. Large number of dead cows was seen in trenches (Dairy Global, 2022). Deaths of animals from cold, hunger and injury were confirmed in the contact zoo (TSN, 2022) and the Mykolaiv Zoo (Novoye Vremya, 2022a). Similarly, 300 dogs were reported to have died in the Borodianka Kyiv oblast (The Village, 2022). According to the Ukraine’s Minister of Environmental Protection, “since February, 120 deaths of dolphins in the Black Sea are documented having links to the war” (Rannard, 2022). Other report by Early (2023) quoted Ukraine’s Environment Minister claiming death of at least 700 Black Sea dolphins, which became victims of acoustic trauma caused by sonar equipment of Russian submarines.

**Loss of Water Bodies**

Omelchuk and Sadohurska (2022) termed the Black Sea a place for theatre of Russian war. The abandoned vehicles pollute sea water with leaking fuel and lubricants, and fuel spills induce fires on water surface (Seibt, 2022). The spilled out oil itself is very toxic to marine life and microorganisms (Seibt, 2022); oil also contains hydrocarbons that dissolve with pesticides or heavy metals leading to its high concentration on the surface of water (Omelchuk and Sadohurska, 2022). Due to the massive movement of naval vessels in the Black Sea, marine ecosystems are affected badly. Tuzlovski Limany Reserve was reported to have the deaths of several thousand dolphins in the Black Sea over 3 months (New York Times, 2022; Odessa News, 2022). Scientists estimated the deaths of about 3,000 dolphins in the Black Sea (UNEP, 2022). Ukrainian Armed Forces claimed 15 ships carrying hundreds of tons of fuel sunk in the open sea and in the port of Berdiansk (Ukrinform, 2022b).
On 26 February 2022, a dam on Irpen river near Kozarovich village was destroyed by Russian troops. It resulted in a flood inundating more than 10 km up to Horenka (NV Kyiv, 2022). According to TMRF (2022), the loss of biodiversity in the Gulf of Odesa, Danube Delta, and Azov Sea is yet to be estimated. Severe pollution was recorded in Seversky Donets river in 2018. Levels of heavy metals and alkylphenols in the river were found 7 times higher than acceptable (Dathan, 2020; UNEP, 2018). During current war, bombs have destroyed Popasnyansky and Uzhnodonbassky waterways, 'Seversky Donets - Donbass' channel, and Donetskaya filtration plant. It was reported that untreated sewage runoff was spilled into the river after pipeline ruptured (PAX, 2022; Roscini, 2022; RYB.RU, 2022).

**Damage to Urban Infrastructure**

Seriously hit is the urban infrastructure. Shelling of missiles has resulted in large quantities of debris in cities and towns in entire country. The Office of the President of Ukraine (2022) and Pereira et al. (2022) claimed that all buildings are either damaged or demolished completely in some settlements. According to Nielsen and Hodgkin (2022), asbestos level from the debris of buildings has gone high in the cities/towns, as the asbestos is used 60 per cent in roofing materials of buildings. Some cases of damages to the urban infrastructure are illustrated as follows:

- Volnovakha (Donetsk oblast) has been destroyed 90 per cent (State Border Guard Service of Ukraine, 2022).
- According to a statement by Kharkiv’s Mayor released on 31 March 2022, at least 1,292 of multi-storey residential buildings were damaged or demolished (Novoye Vremya, 2022b). Mayor’s report quoted 239 administrative buildings, 70 schools, 54 kindergartens and 15 hospitals were partly or fully destroyed as on 31 March 2022.
- UNITAR (2022) published a satellite image of Chernihiv city illustrating the damage to 21% of the city. Simultaneously, the Governor of the Chernihiv oblast reported that 3,500 buildings were damaged in the oblast, from which 80% were residential buildings (Governor of Chernihiv oblast, 2022).
- Territorial communities of Kyiv region informed that 1,875 buildings were either significantly damaged (1,329) or destroyed (546) (Novoye Vremya, 2022b).
- Until 16 April 2022, in the town of Makariv, 28 multi-storeyed buildings, 441 private estates, 8 educational institutions, 4 health care institutions, 8 cultural institutions and 2 sports institutions were destroyed. Likewise, in the town of Borodyanka, 8 out of 29 multi-storeyed residential buildings were completely destroyed and 21 partially destroyed (Kyiv Regional Military Administration, 2022).
- The case of Mariupol is world known. Hardly any building is left undamaged or unburnt, with more than 20,000 residents killed.

Kyiv School of Economics produced a report “Assessment of damages in Ukraine due to Russia’s military aggression as of 1 September 2022”, which presented the data of destroyed and damaged residential infrastructure, as depicted in table 6.
Table 6: Destroyed and damaged units in the residential sector

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>Unit Stock Units</th>
<th>Damaged Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Destroyed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>178,921</td>
<td>6,153</td>
</tr>
<tr>
<td>Private houses</td>
<td>8,984,976</td>
<td>65,847</td>
</tr>
<tr>
<td>Dormitories</td>
<td>7,114</td>
<td>85</td>
</tr>
<tr>
<td><strong>Damaged</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>178,921</td>
<td>9,490</td>
</tr>
<tr>
<td>Private houses</td>
<td>8,984,976</td>
<td>54,069</td>
</tr>
<tr>
<td>Dormitories</td>
<td>7,114</td>
<td>155</td>
</tr>
</tbody>
</table>

Source: de Klerk et al. (2022)

Assuming the reconstruction of destroyed or damaged infrastructure will cause GHG emissions, de Klerk et al. (2022) estimated the emissions. They assumed 100% of the embodied carbon factor for renovation of infrastructure, and 33% factor was assumed for damaged facilities. The projected emissions from destruction and damage of the civil infrastructure are illustrated in table 7.

Table 7: Overview of reconstruction emissions in the civilian sector for various categories

<table>
<thead>
<tr>
<th>Item</th>
<th>Emission, thousand tons CO₂e</th>
<th>Emissions, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential buildings</td>
<td>28,432</td>
<td>58.4</td>
</tr>
<tr>
<td>Social sector</td>
<td>1,055</td>
<td>2.2</td>
</tr>
<tr>
<td>Health care</td>
<td>96</td>
<td>0.2</td>
</tr>
<tr>
<td>Educational and science</td>
<td>2,232</td>
<td>4.6</td>
</tr>
<tr>
<td>Culture, religion, sports, and tourism</td>
<td>1,818</td>
<td>3.7</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>6,006</td>
<td>12.3</td>
</tr>
<tr>
<td>Retail</td>
<td>814</td>
<td>1.7</td>
</tr>
<tr>
<td>Vehicles</td>
<td>2,448</td>
<td>5.0</td>
</tr>
<tr>
<td>Energy</td>
<td>1,314</td>
<td>2.7</td>
</tr>
<tr>
<td>Industry and business services</td>
<td>3,615</td>
<td>7.4</td>
</tr>
<tr>
<td>Utilities</td>
<td>840</td>
<td>1.7</td>
</tr>
<tr>
<td>Total</td>
<td>48,670</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Adapted from de Klerk et al. (2022)

Environmental effects of the destruction of cities appear in the form of huge ecological threats, as the undetonated bombs are buried in debris (Dathan, 2020). The ruined houses release carcinogenic dust for decades (de la Garza, 2022) and millions of tonnes of rubble are of generated having no possibility to recycle (Dathan, 2020).

Implications for European and Ukrainian Energy Sector

Zetterberg, Johnsson and Elkerbout (2022) have simulated policy implications of Russian war in Ukraine in context of rest of the Europe. European security order has ramifications for its entire European economy apart from the transformation of European economies to climate neutrality (Zetterberg, Johnsson and Elkerbout, 2022). Far more than the COVID-19 crisis, some of the immediate challenges to climate...
action policies are raised by Russia’s aggression. Several EU countries have increased defence spending already. This war actually challenged the order and geopolitical landscape impacting climate and energy policies in numerous ways. The issues such as energy security and supply security have reappeared. Energy prices continue to remain high on the political agenda for as long as energy prices are souring, in particular for heating and electricity (Zetterberg, Johnsson and Elkerbout, 2022). Authors like O’Riordan and Sandford (2022) emphasize that the war in Ukraine adds complexity to the global climate change. It manifests more money to be pumped by the west and emerging economies into Russian coffers through purchase of gas, oil, coal and minerals. In fact, 70% of the Russian economy is buttressed by increasing contributions, further flatterng cruel Russian war machine. The authors further articulate that grim and unrelenting climate change politics of corporate dominance confront the world, especially by the fossil fuels-based military complexes (O’Riordan and Sandford, 2022). Associated impact is the inflation and insufferable rises in the living costs.

In particular, some nuclear power plants in Belgium and Germany have prolonged its operations due to energy crisis. Further, dormant coal-fired power plants have been reactivated that bound to increase GHG emissions in the coming years. In August 2022, as de Klerk et al. (2022) documented, “Russia was flaring substantial amounts of natural gas close to the border with Finland as it was not able or willing to supply it to Europe”. Gas flaring is high grade contributor to the global warming (Nwaogu and Akpoghome, 2022).

According to Lloyd’s Futureset (2022), Russian war in Ukraine has disturbed the European businesses and economy greatly while damaging global agriculture and manufacturing, creating further risks to food and energy security worldwide. Some realize that the disruption to critical exports from Ukraine, especially grain exports, threatened significantly global food security. Another important problem has arisen from the refugee flow into Europe from Ukraine. It is the largest since World War II, surpassing the flow of asylum seekers at the height of the Syrian refugee crisis. About 3 million people fled Ukraine during the first 3 weeks of the war broke on 24 February 2022 and this continued to grow as the conflict continues (Lloyd’s Futureset, 2022), and by 31 January 2023, the figure of Ukrainian people fled was above 18 million.

Pecheniuk et al. (2022) highlighted that the Russian Federation's military aggression against Ukraine dealt a significant blow to the development of Ukrainian renewable energy. With the full-scale invasion of Russia, the stable operation of the Ukrainian energy system was threatened; the energy infrastructure of renewable energy facilities was significantly damaged due to the actions of the Russian army. The main capacities of renewable energy (solar, wind generation) are located in the southern and southeastern regions of Ukraine, where active military operations are currently taking place: the invaders primarily attack transformer substations, and power lines, and personnel. Up to 40% of these facilities have already been destroyed or damaged (Pecheniuk et al., 2022). Other estimates indicate that about 90% of power generation is located in the territory where active hostilities are taking place, and the generation of solar power has decreased by 40% (Omelchenko, 2022). Pecheniuk et al. (2022) reiterate that producers of "green" energy operating in Ukrainian market are in a rather difficult situation. It is not only the threats of shelling of stations, but also a significant
limitation of the state-guaranteed support available for renewable energy. According to the experts, assets valuing USD 5.5 billion are currently in the war zone causing significant losses of renewable energy (Demchenkov, 2022). Pecheniuk et al. (2022) further disclose that the renewable energy sector is on the verge of bankruptcy; for example, the National Energy Company "Ukrenergo" owed about USD 0.4 billion by the end of August 2022 to the producers of the industry under the "green" tariff. Usenko (2022) recommends that the State should preserve the industry and develop plans for its development after the war. There is another problem for the industry: the solvent demand for electricity has significantly decreased (Pecheniuk et al., 2022). Ukrainian population consumed 30-40% less energy causing the fall of payments significantly - by 40-45% (Omelchenko, 2022). Thus, the war-generated pathetic situation in energy sector has significantly worsened the energy production. In fact, the Ukraine government does not have the financial means to support the power generation in the current conditions. Funds that enter the state treasury are directed, first of all, to military, humanitarian, and social purposes (Pecheniuk et al., 2022), and they are still not enough.

**Breach of International Law and Human Rights of Peace and Dignity**

International legal regimes are as old as the history of wars. The foundation of the League of Nations (changed to United Nations) in 1945 took place after the World War II. To protect the environment from negative impacts of war, the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques18 was adopted in 1976. This Convention prohibits using the methods of the modification of the environment as a tool of war (Gardashuk, 2022). Both Ukraine and the Russian Federation are signatories to this Convention. Under Article 35 of the Protocol (I) to the Geneva Conventions19, which was adopted in 1977, it is prohibited “to employ methods or means of warfare which are intended, or maybe expected, to cause widespread, long-term and severe damage to the natural environment”. This document20 further states “to protect the natural environment against widespread, long-term and severe damage. This protection includes a prohibition of the use of methods or means of warfare which are intended or may be expected to cause such damage to the natural environment and, thereby, to prejudice the health or survival of the population” (Art. 55). The General Assembly of the United Nations in 2001 proclaimed November 6 as the International Day for Preventing the Exploitation of the Environment in War and Armed Conflict in order to curb the environmental harms of the war caused to ecosystems and natural resources (Gardashuk, 2022).

Chowdhury and Rosencranz (2022) informed that 5th Session of the United Nations Environment Assembly (UNEA 5.2) convened in Nairobi, Kenya discussed on global environmental concerns including the reason why the biodiversity and wildlife of Ukraine must bear the brunt of Russian war in Ukraine. Russia remained oblivious to these concerns, and environmental protection was not a major issue for Russia. Meanwhile, the Ukraine's president, Volodymyr Zelensky, urged all EU States repeatedly to stop energy trading with Russia terming it 'blood money' fuelling the

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18 [https://www.un.org/disarmament/enmodal/](https://www.un.org/disarmament/enmodal/)


Russian war machine. Estimates indicate that sale of Russian oil and gas accounts for $1 billion per day (Chowdhury and Rosencranz, 2022). Lloyd’s Futureset (2022) has assessed the emerging scenarios globally as a result of war. Their report (Lloyd’s Futureset, 2022) exclaims that the geopolitics has undergone a crisis exhibiting the vulnerabilities coupled with globalisation in an international system wherein a powerful State asserts self-interest and breaches international laws. Resultantly, emerging world order pushes many organisations to adopt hedging strategies protecting global self-interests and assets since increasingly protectionist trade policies are introduced (Lloyd’s Futureset, 2022). It implies that various countries and businesses are gearing to grab supply chains in order to achieve self-sufficiency and extended control on access to priority goods and services. This trend of trade and specialisation will inevitably add to the inflation in the long term (Lloyd’s Futureset, 2022).

In Daily Maverick, Ngcuka (2022) wrote explicitly, “United Nations member states attending the UN Environment Assembly’s opening session have raised concerns over the environmental impact of the Russia-Ukraine crisis. Russia says they are hypocrites. The resumed fifth session of the United Nations Environment Assembly (Unea 5.2) got underway in the Kenyan capital, Nairobi, with some world leaders condemning the Russian invasion of Ukraine and raising concerns over the environmental impact of the conflict. Russia called the concern “hypocrisy”. The meeting coincides with the release of the sixth report of the International Panel on Climate Change. It details the grim effects of the climate crisis on humanity, biodiversity and marine life. While environmental concerns over the conflict cast a shadow over the world’s highest-level decision-making body on the environment, urgent concerns were raised over the triple threat of the climate crisis, loss of biodiversity and pollution” (Dhingra, 2022).

Bazhenova (2022) elaborated that the Protocol Additional to the Geneva Conventions of August 12, 1949 for the Protection of Victims of International Armed Conflicts (Protocol I), adopted on June 8, 1977 enforces warring States (e.g. Russia) are obliged to protect the natural environment against “widespread, long-term and severe damage”. The warring States cannot employ warfare intended to cause or causing such environmental damage threatening the health or survival of the population. Similarly, Principle 24 of UNCED 1992 instructs that warfare inevitably has a destructive impact hampering the process of sustainable development. It implies that the States must respect international law obliging to protect the environment in times of armed conflicts (Bazhenova, 2022). From all the angles, it is observed that Russia does not adhere to the obligations of international conventions defining the rules of warfare, and, thereby, destroying the environment. Within 3 months of war since 24 February 2022, Russian military committed 245 crimes against the environment recorded only in Black Sea (Bazhenova, 2022). It was a loss of approximately USD 6.8 billion. Within these 3 months, the largest number of cases of ecocide was reported in Kyiv (34), Donetsk (28), and Dnipropetrovsk (22) and Luhansk (22), apart from over 1,500 cases of environment damages that were recorded as a result of Russian missile explosions (Bazhenova, 2022).
All-Ukrainian Ecological League campaigned\(^{21}\) through national videoconference “Environmental Threats and Risks to the Environment, Life and Health from Russian Military Aggression” to discuss the environmental challenges of the war and to work out and document environmental crimes of Russian Federation, and the notes were submitted to the International Criminal Court.

According to the International Association of Applied Psychology (IAAP), Russia’s aggression against Ukraine also violates the *Universal Declaration of Human Rights* 1948, which proclaims that freedom, justice, and peace in the world rest on honouring the inherent dignity and fundamental rights of all members of the human family including but not limited to “the right to life, liberty and the security of person” (IAAP, 2022).

**Part-B: Psychology Effects of Russian War in Ukraine**

Anjum, Aziz and Hamid (2023) have rightly highlighted that recent Russian invasion in 2022 and 2023 has led to the world’s largest war-led humanitarian and mental health crises among Ukrainians. Foremost psychological symptom of the war appears in the form of fear and uncertainty followed by direct threats to peoples’ lives. The same was observed when the full Russian invasion began on 24 February 2022. IOM (2022) observed common sufferings in the following forms: 1) fleeing homes in search of safety and living through repeated displacement, 2) being a refugee in a foreign country without knowing the language, 3) hiding in the basements from shelling, 4) trying to earn for families after losing a job, 5) being separated from loved ones, 6) facing outages of power and electricity. Among these sufferings, number 3 and 6 are common for all, people migrated and people living in Ukraine during the war. IOM (2022) emphasizes that all these stressors contribute to anxiety, panic, mild or severe depression, insomnia and other stress-related disorders that severely affect public health.

**Long-Term Stress and Trauma**

War causes long-term environmental stress, which is harmful to human’s health. Various authors have described ‘environmental stress’ referring to factors in a person’s surroundings or environment that can cause emotional or mental strain in their lives (Washmuth, 2022). Causing the environmental stress, the environmental stressors are external and they can often lead to increased levels of discomfort, anxiety, and aggression. War, pollution, noise and fire are the causes of environmental stress (Washmuth, 2022). However, appropriate responses of the victims of pollution from war munitions rely upon both the temporal and spatial attributes of the environmental shocks and the characteristics of the person encountering them (Angilletta Jr. and Sears, 2011). Nevertheless, ecological stress may occur as an intense, short-lived event of destruction (from war) called a disturbance. Inevitably, damage in terms of psychological responses happens when one or more stressors elicit reactions known as ‘degradation of environmental quality’.

Psychological direct impacts of war and the direct/indirect impacts of environmental damages are inseparable. Opaas (2022) emphasize that the war victims struggle for survival when their life is under risks. Occupational health of the people is affected severely by sirens, aeroplane sounds and bombning by missiles or rockets. Mental distress and trauma are major constituents of occupational health and well-being. Severely threatening situations, including those generated from excessive air pollution, nuclear risks, sound pollution (as a result of planes, rockets and bombning), and fires create fear, sleeplessness, sleep disturbance, irritation, anxiety, nightmares, somatization restlessness, jumpiness, physical arousal, high bodily activation, being alarmed and on guard, helplessness, and physical experience of numbness (Almoshmosh, 2016; Balaban et al., 2005; WHO, 2015). Hodes (2022) suggested additional emotional reactions that include shock, disbelief, grief, anger, irritability, anxiety, fear, detachment, and insecurity.

At the human personal level, such difficult experiences lead to severe consequences in the form of post-traumatic stress disorder (PTSD), depression, and anxiety (Javanbakht, 2022). In the words of Javanbakht (2020), “the PTSD symptoms include terrifying and realistic flashbacks of war scenes, intrusive memories of the trauma, panic, inability to sleep and nightmares, as well as avoidance of anything that resembles the trauma”. According to him, a lot of research is focused on environmental factors, such as war, lead to development of PTSD in a person having visible anxiety, feelings of danger, nightmares disrupting the sleep, flashbacks or sensory experiences, intrusive traumatic memories, irritability, emotional numbness, social withdrawal, and avoidance of any reminder of trauma (Javanbakht, 2020). Studies by Fel, Jurek and Lenart-Kłoś (2022) show that women are at a higher risk of PTSD. Ukrainian women who are living in limbo of the war reflect higher PTSD which is outcome of violence and damage caused by war but also of other stressful circumstances, such as social and financial conditions (Fel, Jurek and Lenart-Kłoś, 2022).

Impacts on Children

Onset of war pushes children to suffer both acute and chronic traumatic stress. Children’s suffering can be understood within an ecological framework underlying 5 elements: the child's psychobiological makeup, the disruption of the family unit, the breakdown of community, and the ameliorating effects of culture (Elbedour, ten Bensel and Bastien, 1993). Javanbakht (2022) articulates that children are specifically vulnerable to the effects of war. They imagine the terror in a dark basement, often watching the faces of their parents praying that the next missile will not hit their building. Of course, the parents can shield their children against trauma only to some extent (Javanbakht, 2022). Basner, Clark and Hansell (2017) have suggested that children exposed to regular aircraft noise have poor performance on standardised achievement tests conducted in schools.

Psychological Effects Noise Pollution Caused by War

During the war, noise is intensely created by aeroplanes, rockets, missiles, bombnings, tanks, and ammunition. Noise pollution from the war creates anxiety, depression, high blood pressure, heart disease, and stroke. The health disorders connected to noise
uneasiness, wretchedness, hypertension, heart sicknesses and strokes, restlessness, depression, anxiety, insomnia, and psychosomatic disorders (Watkins, Tarnopolsky and Jenkins, 1981). Noise has diverse negative impacts on the performance of human being. According to Basner et al. (2015), non-auditory impacts of noise include perceived disturbance, irritation, cognitive impairment, cardiovascular issues and sleep disturbance (Muzet, 2007). Studies show that noise causes psychological debilitation and oxidative stress in the brain. It has been seen that exposure to noise impacts the central nervous system (CNS) leading to extreme stress, anxiety, intellectual and memory problems. Some of the physiological signs are also recorded: (a) Signals related to the peripheral nervous system, including heartbeat and Electromyogram; (b) Signals related to the central nervous system including electroencephalography (EEG). Hegewald et al. (2020) found recent evidence showing a depression risk increased significantly from aircraft noise. Stansfeld et al. (1996) found that individuals with high noise sensitivity suffer from hypertension and emphysema, whereas cardiovascular mortality levels are increased in noise-sensitive women. Stansfeld et al. (1996), Shepherd et al. (2010) and Iwata (1984) have reported an association between noise sensitivity and various mental health-related factors, such as anxiety, depression, higher benzodiazepine usage, and future psychiatric disorder.

Noise and social behaviour are very well connected. The noise created by war machinery has detrimental effects on cognitive processes along with social behaviour. Due to the increasing degrees of noise, lower levels of social interaction (Appleyard and Lintell, 1972), increased aggressiveness (Adelson, Geen and O'Neil, 1969) and lower levels of altruistic behaviour (Mathews and Canon, 1975) were recorded. More aggressive behaviour of common Ukrainians during the war is a general negative effect of the noise. Noise has also been shown to be a factor attributed to violent reactions (Elizondo-Garza, 1999).

**Psychological Effects of Air & Chemical Pollution Created by War**

In the part-A of this article, a lot is written about the environmental impacts of Russian war in Ukraine. Massive air pollution is dangerously causing toxic effects on humans, animals and ecosystem. The psychological effects of air pollution are leading to psychiatric symptoms, including anxiety and changes in mood, cognition, and behaviour (Lundberg, 1996). It is reported by Lundberg (1996) that numerous toxic pollutants interfere with the development and proper functioning of the nervous system, with prominent symptoms of asthma, psychosocial stress, and neurotoxic effects. Dzhambov et al. (2018), Manalisidis et al., (2020) and Ventriglio et al. (2021) illustrated that inhalation of air pollutants can have major consequences on the human central nervous system and neuro-behavioural mechanisms of human population.

Because different types of pollutants have different toxic effects in human body when inhaled, Thomson (2019) articulated that air pollution, especially smog or PAN (per acetyl nitrate) create risks for cardiovascular and respiratory morbidity and mortality. Russian war in Ukraine has built up highest doses of toxic substances (e.g., nanoparticles, particulate matter, NOx, sulphur oxides, etc.) that cause neurological and psychiatric disorders, such as cognitive decline, dementia (including Alzheimer's disease), anxiety, depression, etc. Thomson (2019) has rightly highlighted the adverse
impacts of air pollutants on human’s central nervous system causing early initiating events triggered by gases inhalation, contributing to the disease progression. In a study conducted recently, Abed Al Ahad et al. (2022) reported poor mental well-being observed with every 10μg/m³ increase in NO₂, SO₂, PM₁₀ and PM₂.₅ pollutants in UK. If we compare this with reported levels of similar pollutants in Ukraine (Zalakeviciute et al., 2022) during initial months of war, O₃ was found 2.45% higher in overall Ukraine and 3.38% higher in Kyiv; and SO₂ was 38.06% higher in overall Ukraine with 10% higher in Kyiv. There are an increasing number of studies confirming the adverse effects of air pollutants on the psychiatric disorders among citizens. For example, exposure to NO₂ and particulate matter (PM₁₀ and PM₂.₅) in the Netherlands was found causing poor mental health and anxiety (Klompmaker et al., 2019). One study in South Korea recorded an increased exposure to NO₂, SO₂, and PM₁₀ pollutants resulted in higher frequency of suicide deaths (Jin-Young, Hye-Jin and Kyoung-Bok, 2018). A recent systematic review and meta-analysis by Braithwaite et al. (2019) revealed that exposure to PM₂.₅ pollution increases the risk for depression and anxiety with a pooled odd ratio estimate of 1.10 for every 10 μg/m³ increase in PM₂.₅ concentration.

The science of air pollutants is quite complex. Calderón-Garcidueñas et al. (2015) narrated that war created particulate matter of small diameters, such as PM₂.₅, has potential of initiating oxidative stress and forming inflammatory cytokines that infiltrate the blood-brain barrier producing neuro-degeneration and neuro-inflammation. Abed Al Ahad et al. (2022) indicates that the aesthetic and odorous nuisance caused by air pollution clouds results in avoidance behaviour and inhibition of psychological-supporting outdoor activities, thereby, leading to low happiness, high stress, anxiety, loneliness, and poor mental well-being (Claeson et al., 2013; Lu, 2020). Various negative impact are seen of air pollutants on human’s physical health along with higher risk for acute and chronic diseases, such as cardiovascular, respiratory, cancer and immune system diseases. Moreover, people residing in excessively polluted areas experience stress and anxiety, and poor mental well-being (Abed Al Ahad et al., 2020; Manisalidis et al., 2020). Petrowski et al. (2021) established a linkage between air pollution of particulate matter having aerodynamic diameter smaller than 10 µm (PM₁₀) and the effects on determinants of mental health and well-being (life satisfaction, stress resilience, anxiety, depression, and self-esteem). The correlation was positive.

Ukraine is the hub for chemical producing industries, including the storage depots. As a result of bombing and missile attacks, chemical factories, fuel stations, chemical storages, and toxic substances depots have been destroyed causing tremendous spillage of organic and inorganic substances. Among the organic substances are persistent organic pollutants (POPs), especially dioxin, polychlorinated biphenyls (PCBs), and chlordane. Many chemical contaminants are classified as known neurotoxic substances. There are thousands of potential neurotoxic substances that are associated with mental health developmental disorders of the brain (Lyssikatou and Oikonomou, 2020). Such toxic chemicals are known to cause depression and anxiety following chronic exposures (Brown Jr., 2013). However, non-persistent organic chemicals (mostly inorganic chemicals) cause more severe psychiatric symptoms (depression, anxiety, mania, psychosis, and aggression) following the acute and chronic exposures, particularly to organophosphates (OPs), organo-metals, and
solvents (Brown Jr., 2013). War has caused mass chemical disasters in industrial settings, individual chemical accidents, targeted destruction of production centres. The consequences of the chemical pollution caused by the war will be known in coming years.

**Psychological Effects of Radioactive Pollution Caused by War**

Radioactive pollution was caused heavily from Russian war in Ukraine in Chernobyl and Zaporizhzhia. Russians took no lesson from world’s most dangerous nuclear disaster occurred in Chernobyl of Ukraine. The same Chernobyl was occupied by Russians during initial days of their invasion in Ukraine, although it backfired themselves. Despite past dangerous incidences, not only the threats for nuclear explosions are continuing but sporadic damages of nuclear power stations are done by Russian forces. This scary warfare is causing tremendous psychological stress, anxieties, fear and concerns among the common people and the Ukrainian government. In the subsequent paragraphs, the impacts of radioactive pollution documented in Chernobyl of Ukraine and sporadically in others parts of the world are highlighted to understand the unseen and envisaged scenario of mental health in the event of nuclear disaster caused by Russian war in Ukrainian territory.

Mental health of people exposed to the radiation is a subject of classical neurobiology. The first and foremost psychological effect generates from the panic created from the information of the nuclear disaster or radioactive fallout. The moment news spreads about land, water, air and food polluted by deadly and invisible radioactive contaminants, there is a panic among the people to protect their life, particularly their children and unborn babies. Chernobyl nuclear disaster of 1986 in Ukraine forced the humans to evacuate from a radiological or nuclear accident area led to social isolation, anxiety, depression, psychosomatic medical problems, reckless behaviour, and suicide. As a consequence of nuclear disaster, not only the psychological danger put people at risk but serious health concerns also worry them. Occurrence of cancer and other deadly illnesses is commonplace. In cases of emergencies, it is observed that many thousands of radiation emergency survivors subsequently undergo to develop PTSD, depression and anxiety disorders (Martin, 2015). The consequences of low-level radiation are far-reaching and often more psychological than radiological. It is because the damage from very low-level radiation cannot be detected; and hence people remain in uncertainty about what would happen to them. Fears continue to penetrate among the human brains that they have been contaminated for life and may have birth defects.

Study by Bromet (2014) on the emotional consequences of nuclear disasters is a classical work to warn all of us. The author found that populations affected by Chernobyl accident show enduring impacts on emotional well-being, manifested in terms of depression, anxiety, PTSD, poor self-rated health, and medically unexplained symptoms (Bromet, 2014). According to her, “overall, the rates of psychological impairment range from 25–75%, depending on the population under study, the timing of the assessments, the perceived or actual magnitude of the exposure, and the degree of direct involvement with the accident”. Similar findings were recorded by Bromet et al. (2005) indicating that the lifetime prevalence of depression in women in Ukraine was 20.8%, while the lifetime prevalence of depression in women 11 years after
Chernobyl was 46.7%. In 1986, Chernobyl accident resulted in a meltdown and extensive contamination of regions of Ukraine, Belarus, and Russia. Apart from 31 deaths amid emergency clean-up, permanent evacuation of nearly 200,000 residents was followed by a marked increase of thyroid cancer among young children occurred from contaminated milk (Bard, Verger and Hubert, 1997).

Ionizing radiation is identified as a potential risk factor for cognitive dysfunction. The impact on mental health, for example, is the largest public health consequence following the Chernobyl disaster (Bennett, Repacholi and Carr, 2006; IAEA, 2006) with reported increased levels of anxiety and depression among the citizens (Danzer and Danzer, 2016; Ginzburg, 1993; Pastel, 2002). The term radiophobia was coined to denote the fear of radiation exposure from the Chernobyl disaster (Pastel, 2002). ‘Phobia’ is an excessive or unreasonable persistent fear regarding an object or situation (American Psychiatric Association, 2013). Another nuclear disaster, Fukushima, has caused the psycho-societal impact (Kamiya et al., 2015) not to a significant level. Despite no deaths directly caused by acute radiation exposure in Fukushima disaster (Steinhauser, Brandl and Johnson, 2014), a new term “Radiation-anxiety” was introduced, which pertains to the negative cognition regarding the potential adverse health effects following the radiation exposure (Fukasawa et al., 2017). Both the radiophobia and radiation-anxiety have been observed during the current Russian war in Ukraine.

Wirtz and von Känel (2017) established a clear link between psychological stress and the cardiovascular risk-factors induced by vascular inflammation. Anxiety is believed to cause high blood pressure (Tully, Cosh and Baune, 2013), which is manifestation of stress-induced increased secretion of pro-inflammatory cytokines, such interleukins (IL-6), interferons, and tumour necrosis factors (Hänself et al., 2010). Caused by nuclear pollution incidents, increased psychological stress and systolic blood pressure are recorded in both exposed and ‘potentially-exposed’ individuals (Collins and de Carvalho, 1993) following the Goiânia (Brazil) accident22. The Fukushima nuclear accident was also found increasing systolic blood pressure in both evacuated male residents and non-evacuated male and female residents (Ohira et al., 2016). Similarly, among the Three Mile Island residents, a higher systolic blood pressure and an increase in anxiety symptoms were also observed (Davison et al., 1991). In terms of neurobiology, the psychological stress affects vascular inflammation, endocrine factors, and subsequently cognitive functioning contributed by potential low/moderate-dose radiation exposure. In fact, the neuro-inflammation (Solleiro-Villavicencio and Rivas-Arancibia, 2018) and vascular inflammation (Balselet et al., 2016) are caused by reactive oxygen species (ROS) and reactive nitrogen species (RNS) produced as a result of direct ionised radiation exposure.

**Psychological Effects of Fire Caused by War**

Russian war in Ukraine has set on fire all types of complexes: industrial, offices, residential, government, civilians, military, agriculture fields, storages, fuel stations, hotels, and so on. From all the fires the Ukrainian people are severely affected: in terms of surviving and escaping from fire, loss of property, fire hazard, and heat

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22 https://en.wikipedia.org/wiki/Goi%C3%A2nia_accident
23 https://en.wikipedia.org/wiki/Three_Mile_Island_accident
manifestation. Among the Ukrainians, residential fires lead to significant emotional distress apart from possible physical injuries or efforts to save lives. So, the fires do cause emotional distress as well as physical damage. The fires threaten life and property and are unpredictable, uncontrollable, and terrifying (Penney, 2016). The children are affected often by what they see during and after a fire, whether or not they are physically injured. Most important is that the fire causes traumatic events, characterized by emotions of horror, helplessness, serious injury, or the threat of serious injury or death. According to Penney (2016), a traumatic event is perceived and experienced as a threat to one's life safety or stability. It may also involve burns, physical injury or illness, and separation from parents (abandonment), family member, or pet. The fire also leads to hospitalization, anxiety, fear or pain (Penney, 2016). A website24 has rightly pointed out the common emotional reactions after a residential fire. Such reactions include shock, disbelief, anger, fear, loss, despair and hopelessness. Jones et al. (2002) confirmed the consequences of fire that include threat to life or bodily integrity (Green, Grace and Gleser, 1985; Maida et al., 1989; McFarlane, Policansky and Irwin, 1987), severe physical harm or injury (Green et al., 1983), and sudden loss of a loved one (Green et al., 1983; Green et al., 1989).

Existing literature explores the psychological effects of different types of fires – house, residential, industrial, fuel stations, property, office complexes, hotels, wildfires, marine surface fires, and others. As is quoted above, the Russian war in Ukraine has caused literally all types of fires with complex psychological effects on the citizens, including the children.

**Psychological Effects of Urban Infrastructure Destruction under War**

In the war imposed by Russia, large scale destruction and damage of urban infrastructure and properties has occurred. There is massive destruction of properties: office complexes, government buildings, residential buildings, factories, industrial and other buildings. Each of the destructions of urban infrastructure is associated with the psychological distress among the residents and owners of properties. Nakamura et al. (2015) estimated that psychological distress prevalence reported was significantly higher (adjusted OR25 = 1.47 and 1.44, respectively) in the ‘more’ and ‘most’ damaged sub-districts than that in the ‘least’ damaged sub-districts (reference). They further concluded that prevalence of psychological distress in communities with substantial property damage was 1.4–1.5-fold higher than that in community with minimal damage. Chen et al. (2001), Kuwabara et al. (2008) and Cerdá et al. (2013) highlight that property damage is considered a major factor contributing to psychologically unfavourable effects on victims. Başoğlu et al. (2004) reported a significant correlation between levels of property damage and post-traumatic stress disorder. Neither study provided sufficient evidence of a possible association between property damage and long-term psychological distress. Başoğlu et al. (2004), Kuwabara et al. (2008) and Oyama et al. (2012) indicated that the mechanism by which property damage increases the risk of psychological distress is complex. They further argue that property damage can lead to several factors or events causing psychological distress, including financial problems, living at a relative's home or

24 https://www.alldryus.com/fire/common-emotions-after-house-fire/
25 Odd Ratio
temporary housing, loss of social contact, and injury to self or family members (Başoğlu et al., 2004; Kuwabara et al., 2008; Oyama et al., 2012).

There is lot of gap in understanding the psychological perspectives of the war-caused infrastructural damages. In context of Russian war in Ukraine, data on psychological consequences will arrive immensely once the war ends or the ceasefire is in place.

**Other Psychological Effects**

There are many other environmental damages occurred as a result of war, and, obviously, various studies do exist establishing psychological impacts of water/marine pollution, pesticides pollution, soil pollution, wildlife killing, nature destruction and ecosystem degradation and so on. However, linking the war, there is a vacuum of literature on different environmental damages and degradation. There are plenty of studies undertaken to assess environmental damages from World War II, but not in psychological contexts.

Climate change and warming temperatures will accrue not only in Ukraine but in entire Europe primarily. Human psychology and rising temperatures and erratic rainfalls, and resulting floods and droughts, do have an intimate connection. American Psychological Association (APA) created a Task Force to study the ‘Interface between Psychology and Global Climate Change’ in 2008 and 2009, and the Task Force produced a report titling, “Psychology and Global Climate Change: Addressing a Multifaceted Phenomenon and Set of Challenges” 26. Doherty and Clayton (2011) noted the psychological consequences of climate change and described 3 classes of psychological impacts: 1) direct (such as traumatic effects of extreme weather and a changed environment), 2) indirect (such as threats to emotional well-being based on observation of impacts and concern); and 3) psycho-social (e.g., chronic social and community effects of heat, drought, migrations, and climate-related conflicts).

Riad et al. (2022) have recently studied anxiety and depressive symptoms among university students in the Czech Republic following the Russian war in Ukraine. They reviewed the situations of individuals affected by war who suffered high risk of mental health, including post traumatic disorder (PTSD), anxiety, and depression (Morina et al., 2018). Under the war imposed by Russians, damage to properties or other valuable assets, death of a close one, displacement of the family, lack of mental preparedness for man-made disaster, lack of social support, and negative coping skills, are the factors contributing to affect the mental health of Ukrainian people (Bryant, Schnurr and Pedlar, 2022). Bogic, Njoku and Priebe (2015) reviewed systematically the mental health issues and found that psychological disorders, such as PTSD, depression, and unspecified anxiety disorders, tended to be highly prevalent among war refugees even after long period of resettlement.

A report by WHO (2022) also indicated the exacerbation of chronic mental health problems and high levels of PTSD, depression, and anxiety among war affected population of all ages in Ukraine. Jawaid, Gomolka and Timmer (2022) wrote an

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important letter to Nature stressing upon the trauma accruing from Russian invasion. Their words are worth mentioning in following quote:

“Ukrainian residents have been facing ‘complex trauma’ which combines multiple exposures to trauma, often in a sequential fashion. These individuals are constantly exposed to several forms of trauma: fear of losing life and/or freedom, grief, separation from families, social isolation, social disruption and forced migration, to name a few. Even when these exposures occur in an isolated form, they have long-term sequelae for human psychological and physical health. These sequelae include an increased risk of post-traumatic stress disorder, depression, and anxiety disorders, as well as physical ailments.”

General psychology of Ukrainians has and will have a profound effect as a result of war. How the decline of green forests from Carpathian Mountains will affect the mindset of people is explained by Khrushch (2021). Further, Khrushch and Karpiuk (2021) strongly argued that a person’s level of psychological state depends on overall surrounding (e.g., good or evil, improvement or destruction, augmentation or wastage) and environmental situations (see also Khrushch, 2013, p.5). In their article, “Psychological Peculiarities of the Ukrainian People in Context of Globalization and Transformations”, Pecheniuk, Pecheniuk and Arjjumend (2022) acknowledged that Ukrainians are adaptable, flexible, hospitable, and sociable, since they are pragmatic, inherently intuitive, hardworking, versatile, and creative. However, their all the productive features are suppressed and crushed under the war and its long-term impacts.

**Conclusion**

For almost 8 years, Russian Federation waged war against Ukraine after occupation of Crimea in 2014. This war was continuing in eastern parts of Ukraine where environment has been the casualty apart from human beings and animals. Then, from 24 February 2022, Russia invaded Ukraine with full-scale war having massive negative impacts on natural environment and human life. No doubt, the Government of Ukraine, security forces and territorial armies in Ukraine have first priority of saving human lives. The environment is the biggest casualty as a consequence of Russian war imposed on Ukraine. Mass destruction of the industrial and civil infrastructure, chemical and air pollution, radioactive pollution, ammunition and missiles caused fires, forest and agriculture damages, wildlife and biodiversity loss, and contamination of waters and soil will make Ukrainian lands inhabitable during and after the war. Examples of World War II are in front of humanity. Plenty of areas in Europe are unusable and inhabitable after almost hundred years. This massive destruction of environment in Ukrainian territories by Russians will deform the whole Ukrainian society not only in economic and infrastructural terms but also in terms of survival, health, psychology, social fabric, and man-nature relations. Diseases like cancer, tumours, mental sicknesses, depression, anxiety, trauma, fear, irritation, stress, high blood pressure, cardiovascular disorders, post-traumatic stress disorder, have already increased among Ukrainian population. Nearly 18 million people have left their homes and fled to neighbouring European countries where they mostly live as refugees. Over 8 million people are internally displaced. It is not unreal to say this war is the largest human tragedy ever seen by the world both in terms of environmental destruction and human psychological disaster.
Although no systematic and enough data and information do exist as yet (as the war deprives the research and information collection) both on environmental aspects and human psychology, this paper has tried to build the analysis on the basis of scarcely available literature. The reviewed composition under this paper on the environmental consequences and psychological effects of environmental damages will galvanize and catalyse the academic and research community to investigate and document further on this subject. This will also motivate active global citizens to raise voices against the Russian invasion so that the environment, human lives, wild and domestic animals, natural ecosystems can be saved. Last, but not least, entire world must come forward to stop Russian invasion and war against humanity to save entire Europe from the phenomenon of rising temperatures and climate change. Obviously, this war is adding enormously to the warming of not only the Northern Hemisphere but also the globe. The horrors created by madness of Russian war machinery must be stopped to save Ukrainian broken human psychologies, now spilled over across Europe and North America.

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Authors’ Declarations and Essential Ethical Compliances

Authors’ Contributions (in accordance with ICMJE criteria for authorship)

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<tr>
<th>Contribution</th>
<th>Author 1</th>
<th>Author 2</th>
<th>Author 3</th>
<th>Author 4</th>
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<th>Author 6</th>
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<tr>
<td>Conceived and designed the research or analysis</td>
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<td>Wrote the article/paper</td>
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