

ECON 494 Spatial Data Science

Project Report

“War in Ukraine” One Year On, Nowhere Safe

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1 Project Description

Our project aimed to analyze the Ukraine conflict using spatial analysis and maps generated through data from ACLED (Armed Conflict Location & Event Data Project). Focusing on the violence targeting civilians after invasion of Russia into Ukraine, we utilized R programming to extract and visualize the conflict data, enabling us to present a comprehensive overview of the events and their spatial distribution.

2 Introduction

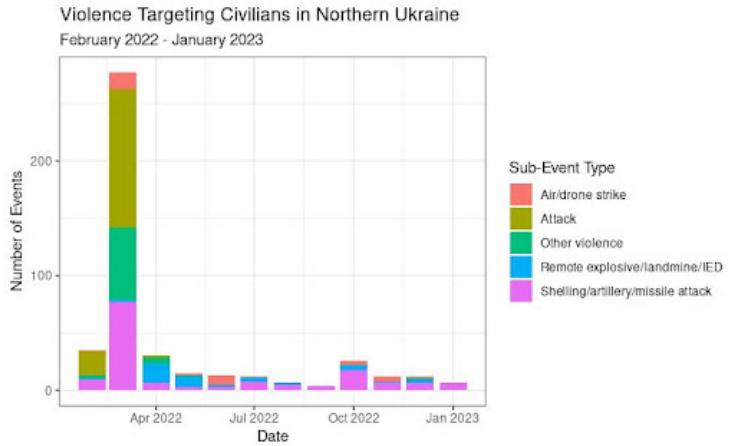
Russia invaded Ukraine in February 2022, resulting in the highest levels of political violence recorded in a single country by ACLED. Civilians in Ukraine have faced shelling, indiscriminate strikes, deliberate attacks, and harsh treatment in occupied areas. Russian forces targeted Kyiv but retreated in northern Ukraine while quickly seizing territories in southern and eastern regions. Over 5,000 reported civilian fatalities have occurred, but the actual toll is likely much higher. Different regions of Ukraine experienced varying levels of violence and occupation during the conflict.



3 Apparent War Crimes in Northern Ukraine

In northern Ukraine, ACLED records over 400 incidents targeting civilians, with a significant number occurring during the Russian advance and subsequent occupation. Shelling, artillery, and missile attacks were the most common types

of violence, but direct attacks on civilian populations resulted in the highest number of reported civilian fatalities. Mass graves were discovered following the Russian retreat. The Kyiv region, including the city of Kyiv, was most affected by these strikes, while the Sumy region continued to suffer from strikes along its border areas with Russia throughout the year. Incidents related to accidental detonation of mines and explosives continued to occur during and after the invasion. ACLED records at least 43 such events resulting in at least 34 reported fatalities, with the highest incidence in April and May 2022 in the Kyiv and Chernihiv regions following the Russian withdrawal.

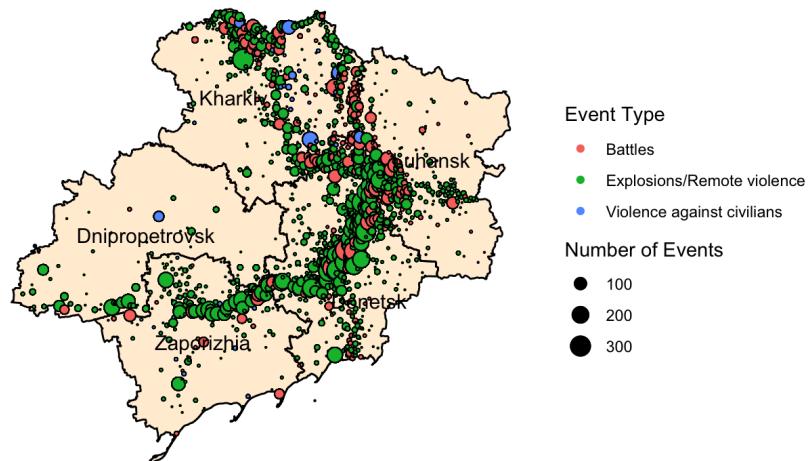


4 Heavy Fighting Along the Frontline in Eastern Ukraine

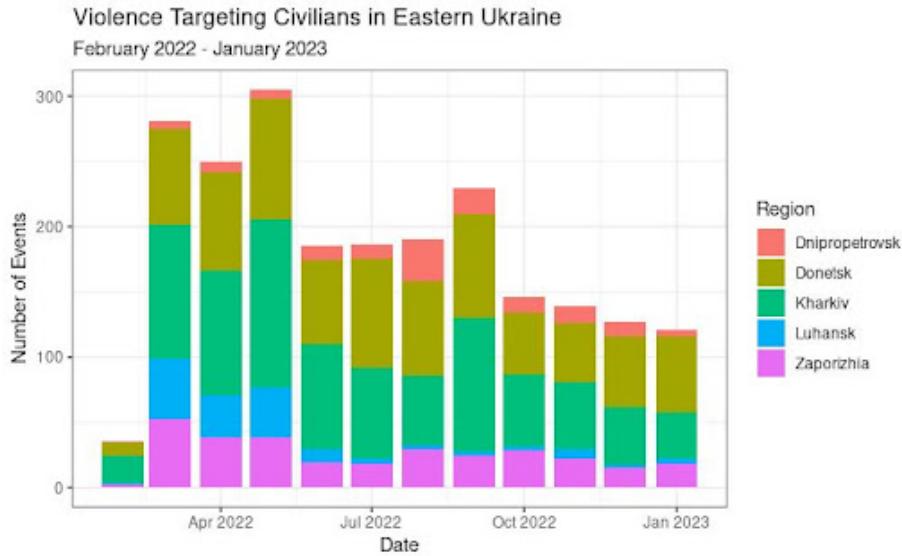
Eastern Ukraine faces unprecedented violence, with three-quarters of political violence events occurring in the region, primarily due to shelling, artillery, and missile attacks. Despite relative distance from the frontline, the Dnipropetrovsk region remains at risk, as Russia continues air and missile strikes, exemplified by the deadly incident in Dnipro on 14 January 2023.

Political Violence in Eastern Ukraine

February 2022 - January 2023

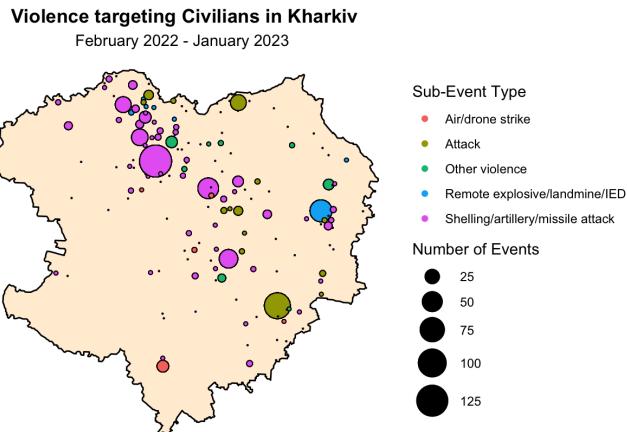


Eastern parts of eastern Ukraine has been highly contested since the beginning of the invasion. The eastern portion of the Kharkiv region, which was occupied by Russian forces, served as a base for their offensives in the Luhansk and Donetsk regions. The Luhansk region experienced intense violence between late February and mid-summer 2022, as Russian forces captured towns by destroying them with artillery. A similar approach was employed in the spring of 2022 to capture Mariupol, the last Ukrainian stronghold in the southern Donetsk region, resulting in dire consequences for both trapped Ukrainian military personnel and civilians. The Zaporizhia region experienced relatively lower levels of armed violence due to Russia's swift occupation in late February and early March 2022.



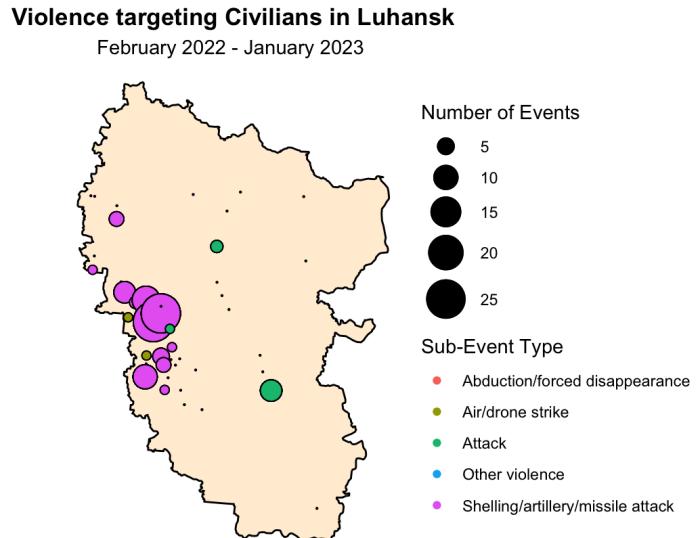
4.1 Kharkiv

Despite failing to break Ukrainian defenses in and around Kharkiv city, Russian forces had taken control of the majority of the northern and eastern parts of the region by April 2022, including the strategically important transport hub of Izium. However, Ukraine managed to liberate almost the entire region in an unexpected counter-offensive in September 2022. Among the more than 800 incidents targeting civilians, approximately three-quarters involved artillery, missiles, and airstrikes, which also accounted for the majority of reported civilian deaths in the region. Around one-third of these incidents occurred in March 2022 alone.



4.2 Luhansk

The extensive use of artillery, missiles, and airstrikes, along with intense close combat, resulted in significant suffering for the civilian population in the Luhansk region. Tragic incidents occurred, such as the shelling of a nursing home in Kreminna on March 11, 2022, which reportedly led to the death of 56 elderly patients. Additionally, an airstrike on a school used as a shelter in Bilohorivka on May 7, 2022, resulted in the loss of at least 60 lives. The shelling of Severodonetsk in March and May 2022 also claimed the lives of over 50 civilians. After the Russian occupation of the region in the summer of 2022, there was a significant decrease in reports of civilians being targeted, although the region has remained highly volatile, particularly since autumn.

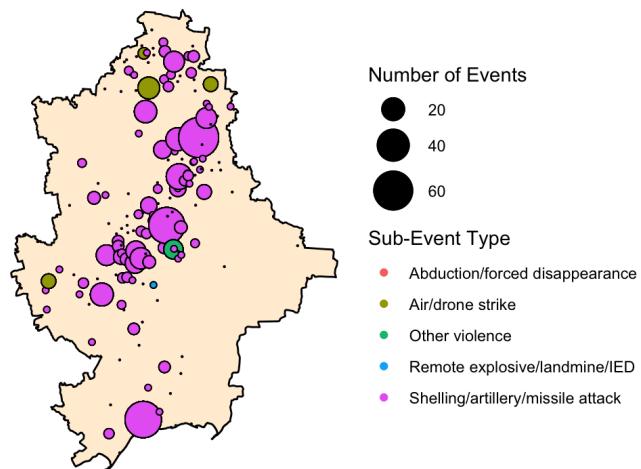


4.3 Donetsk

ACLED data documents more than 16,000 incidents in the Donetsk region, with over 12,000 of them involving shelling, artillery, missiles, and airstrikes. Only a relatively small number of these incidents, around 800, specifically targeted civilians. Prior to the Russian occupation, the city of Mariupol witnessed multiple incidents resulting in significant casualties. Mass casualty events caused by long-range missile and artillery strikes were reported in various areas of the region, affecting both sides of the line of contact.

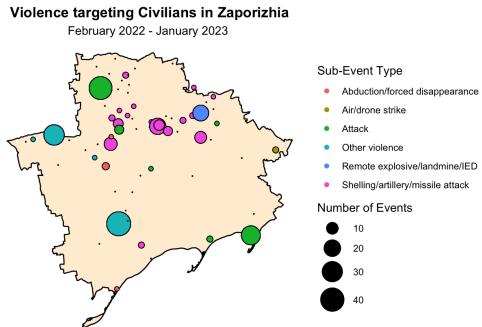
Violence targeting Civilians in Donetsk

February 2022 - January 2023



4.4 Zaporizhia

During the initial stages of the invasion, Russian forces successfully occupied a significant portion of the Zaporizhia region. This included the entire coastline of the Sea of Azov, encompassing the Ukrainian navy base in Berdiansk, as well as an area extending from Kherson to the southern Donetsk regions, reaching the Dnipro river. The occupation also covered Melitopol, the region's second-largest town. Ukrainian forces managed to halt the advancement of Russian forces in the Orikhiv and Huliaipole areas. While approximately half of the incidents targeting civilians in the Zaporizhia region involved shelling, air attacks, and drone strikes, civilians have also been directly targeted. These attacks include firing at vehicles carrying evacuating civilians, as well as instances of torture and execution. In areas under Russian occupation, there are frequent reports of the abduction of local officials, teachers, journalists, Ukrainian army veterans, and civil activists.



5 Explosive Threats for Civilians in Southern Ukraine

Russian attempts for landings from the Black Sea were unsuccessful. Russian forces invaded southern Ukraine from the annexed Crimean peninsula, successfully overtaking the Kherson region and its main city in March 2022. The Kherson and Mykolaiv regions experienced significant violence, with artillery strikes leading to high fatality numbers. The most common types of violence in Kherson were abductions, forced disappearances, torture, targeting primarily officials, journalists, activists, and those suspected of pro-Ukrainian views. In June 2022, Russian forces reportedly abducted about 50 Crimean Tatars from Kherson. Two significant incidents in the Odesa region include a missile strike that killed 8 and injured 10 civilians on April 2022, and an airstrike that killed at least 21 civilians on July 2022.

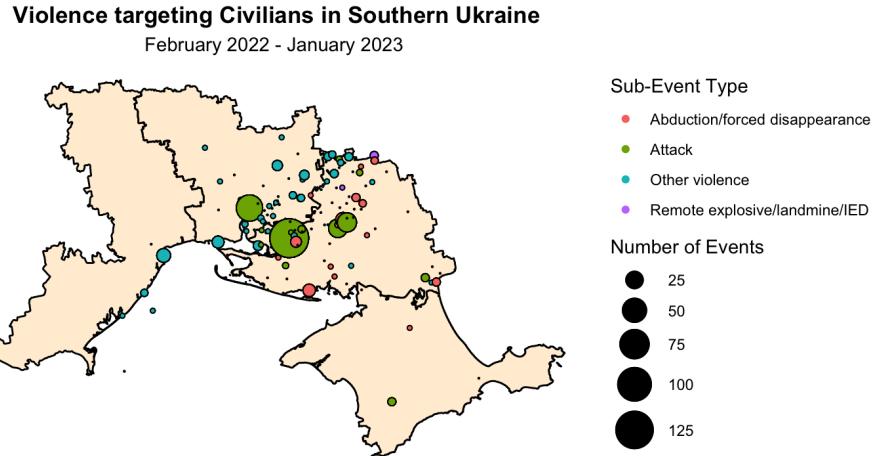


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6 Constant Menace from the Skies in Central and Western Ukraine Conclusion

Over 150 Russian missile, air, and drone strikes have targeted the Central and West regions, posing a significant threat to civilian safety. Approximately one-fifth of these strikes hit civilian areas, leading to over 80 fatalities. Two incidents accounted for most of the reported fatalities: a missile strike on a shopping mall, in Poltava, on June 2022, and a missile strike on a Vinnytsia concert hall on July 2022. At least 50 Russian strikes targeted energy infrastructure deep within Ukraine which caused power outages, with Vinnytsia being one of the most affected regions.

Long-Range Strikes in Central and Western Ukraine

February 2022 - January 2023

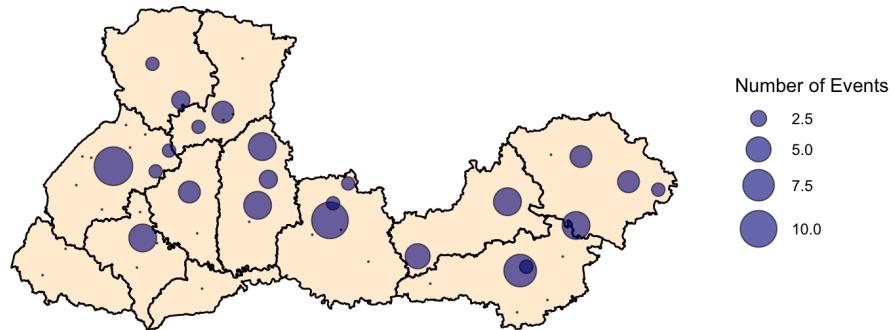


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7 Conclusion

The war in Ukraine has disrupted normal life and defied expectations of a quick subjugation. The aggressive actions of Russia have exposed millions of Ukrainians to violence and hardship. Mass graves indicate potential atrocities in areas under Russian occupation. Contamination of formerly occupied areas with mines poses a serious risk to returning civilians. The war has led to a contraction of Ukraine's economy and internal and external displacement of millions. Remaining civilians face ongoing disruptions to utilities and constant threats of cross-border strikes and shelling. Ongoing occupation of a nuclear power plant by Russia, along with the threats of nuclear weapons, present continuous risks to the lives and environment of Ukraine and the surrounding region.

8 Extended Analysis (2018-2022): *Pre-Invasion Ukraine*

The Euromaidan protests, which started in late 2013, were primarily centered in the capital city of Kyiv (Kiev) but spread to other regions as well. The protests involved clashes between demonstrators and law enforcement, resulting in instances of violence, injuries, and fatalities.

Before the Russian invasion the violence in eastern Ukraine was already concentrated in areas close to the Ukrainian-Russian border, particularly in the

Donetsk and Luhansk regions. Cities such as Donetsk, Luhansk, Mariupol, and Sloviansk witnessed intense fighting and became hotspots of violence.

Both sides of the conflict engaged in military operations, including artillery shelling, sniper attacks, and armed clashes. The violence was not limited to specific cities but was spread across the conflict-affected regions.

The conflict resulted in a significant number of civilian casualties and widespread displacement of residents. Civilians, including those living in towns and villages near the front lines, faced the risk of violence and were often caught in the crossfire.

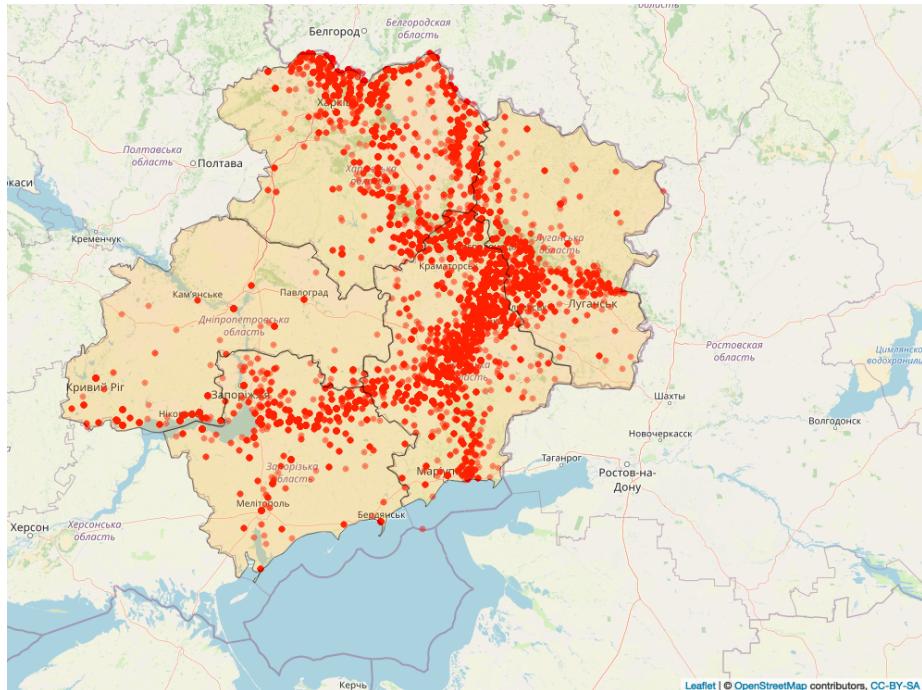


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Violence targeting Civilians in Pre-Invasion Ukraine

Before February 2022

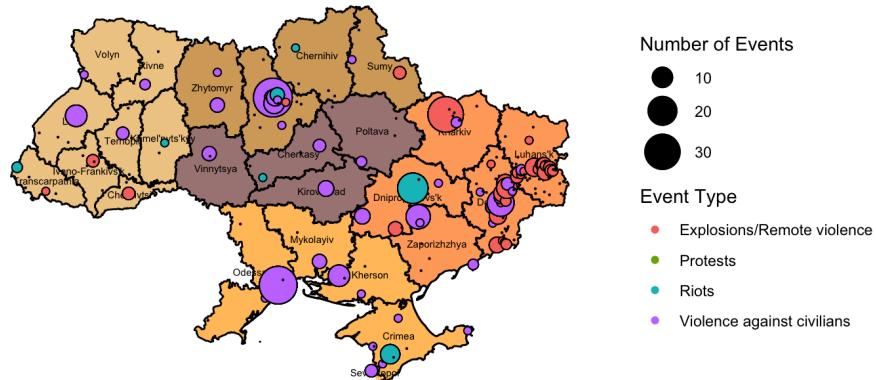


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Political Violence in Eastern Ukraine Pre-Invasion

February 2022 - January 2023

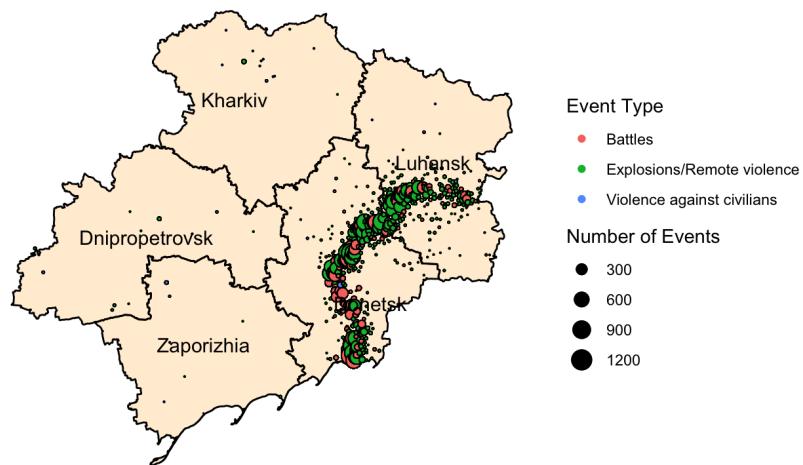


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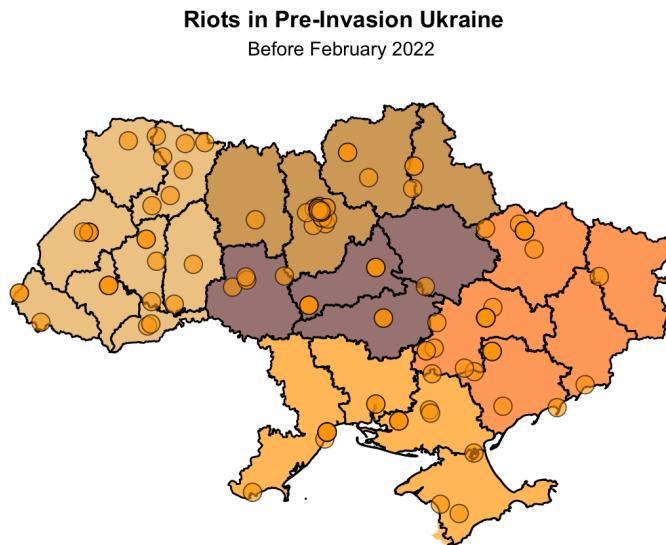


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9 Literature Review

Three works related to conflict in Ukraine and civilian effects have been reviewed in this report to show support and additional analysis of this conflict according to spatial data analysis.

“Near-Real Time Analysis of War and Economic Activity during Russia’s Invasion of Ukraine” work by Yuri M. Zhukov from Department of Political Science University of Michigan presents new near-real-time data regarding Russia’s invasion of Ukraine. The research explores the immediate consequences of occupation and violence on local economic activity. The study utilizes data from remote sensing, specifically nighttime luminosity and vegetation, to assess the impact. The findings indicate a significant decrease in economic activity in areas most affected by combat, as demonstrated by a 50% decline in nighttime luminosity in urban areas that experienced a month of contested control without either combatant gaining full dominance. Additionally, a decline in vegetation on agricultural land was observed in actively contested regions. Contrarily, areas under complete Russian occupation displayed an increase in both luminosity and vegetation.

Figure 3: Summary of Near-Real Time Event Datasets on Ukraine

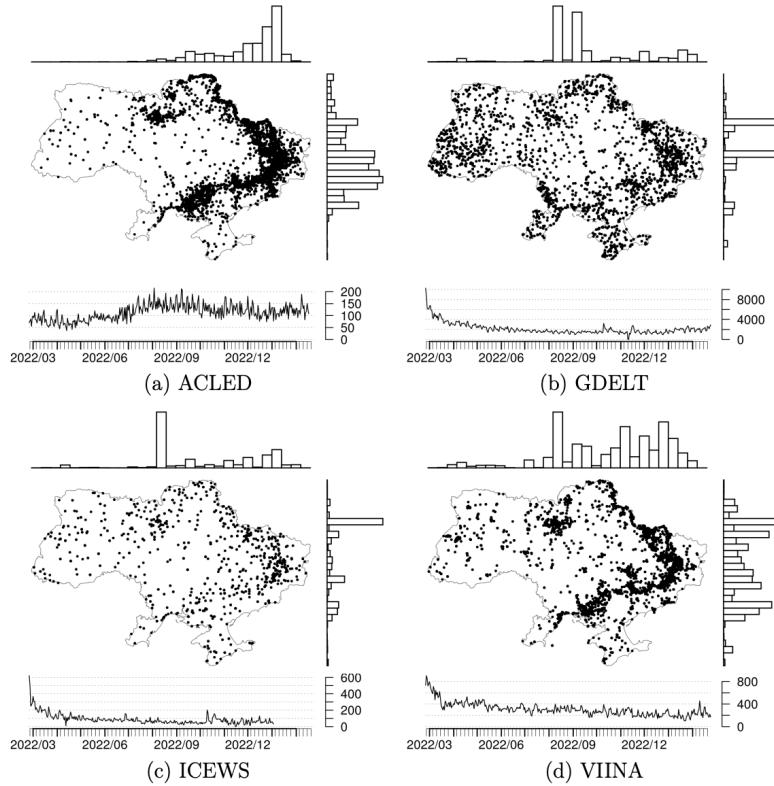


Figure 7: Near-Real Time Analysis of War and Economic Activity during Russia's Invasion of Ukraine

”Quantifying war-induced crop losses in Ukraine in near real time to strengthen local and global food security,” work by Klaus Deininger, Daniel Ayalew Ali, Natalia Kussul, Andrii Shelestov, Guido Lemoine, and Hanna Yailimova, utilizes a 4-year panel (2019-2022) consisting of 10,125 village councils in Ukraine. The study aims to estimate the impact of the war initiated by Russia on the area and expected yield of winter crops, aggregated at the field level. The researchers employ satellite imagery to assess the direct damage inflicted on agricultural fields. While the available data only pertains to winter crops, the findings indicate a potential reduction of up to 4.84 million tons of wheat. When considering both the reduction in area and yield, it suggests a war-induced loss of up to 17% in winter wheat output, assuming a full harvest of the 2022 winter wheat crop.

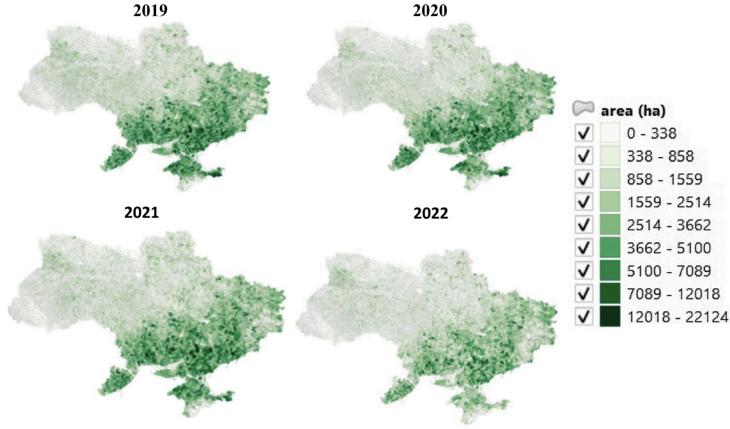


Fig. 2. Map of winter crop cover for 2019 to 2022 growing seasons.

Figure 8: Quantifying war-induced crop losses in Ukraine in near real time to strengthen local and global food security

”Detection of War-Damaged Agricultural Fields of Ukraine Based on Vegetation Indices Using Sentinel-2 Data” focuses on identifying agricultural fields damaged by war using data from the Sentinel-2 satellite. The analysis compares cloud-free composites of the Normalized Difference Vegetation Index (NDVI) before and after active hostilities in specific areas, with dates and locations obtained from the ACLED source. The findings reveal various types of damage to agricultural fields, such as impact craters from explosions and shelling, evidence of machinery, and burnt fields, among others. The identified damaged areas were verified using ACLED data. This information can aid the Ukrainian government and international entities in accurately allocating financial resources to support affected landowners and facilitate the successful and efficient restoration of Ukraine’s agricultural and industrial sectors.

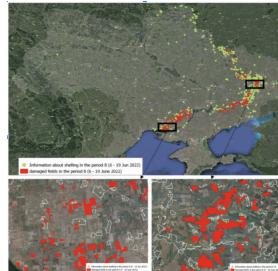


Figure 9: Detection of War-Damaged Agricultural Fields of Ukraine Based on Vegetation Indices Using Sentinel-2 Data

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- [2] Klaus Deininger et al. “Quantifying war-induced crop losses in Ukraine in near real time to strengthen local and global food security”. In: *Food Policy* 115 (2023), p. 102418.
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