AREA BASED RISK ASSESSMENT
BAKHMUT RAION
DONETSKA OBLAST, EASTERN UKRAINE

August 2020

3P Consortium PREVENT PREPARE PROTECT

Funded by European Union Civil Protection and Humanitarian Aid

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The 3P Consortium: Prepare, Prevent and Protect civilian populations from disaster risks in conflict-affected areas

The 3P Consortium, created in 2019, is funded by the Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) and USAID/OFDA

On the occasion of the International Day for Disaster Risk Reduction, the 3P Consortium (ACTED, IMPACT Initiatives, Right To Protection, the Austrian Red Cross, the Danish Red Cross and the Ukrainian Red Cross) launched its programme to reduce vulnerability to disaster risks in Eastern Ukraine by preparing, preventing and protecting civilian populations who are at risk of major disasters.

Civilians continue to bear the brunt of the ongoing conflict in Eastern Ukraine. Shelling, landmines, unexploded ordnances, frequent water and electricity cuts: this is daily life for people living close to the contact line, which splits government controlled areas from non-government controlled areas and where armed fighting continues to take place.

Natural, industrial and ecological hazards present in conflict-affected areas also pose a significant risk to the life and health of millions, and to the resilience of essential service delivery systems. Flooding coal mines, factories exposed to shelling, toxic landfills, chemical spills: these are yet another aspect of daily reality in Eastern Ukraine.

It is to raise awareness about these risks that the 3P Consortium – a group of Ukrainian and international non-governmental organisations (NGOs), was formed in 2019 with financial support from the Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) and the United States Agency for International Development (USAID) / Office of Foreign Disaster Assistance (OFDA).

In 2019 on October 13th, celebrated as the International Day for Disaster Risk Reduction, the 3P Consortium introduced its programme which aims at supporting the Government of Ukraine to fulfill its commitment under the Sendai Framework for Disaster Risk Reduction 2015-2030. The 3P programme aims to reduce vulnerability to disaster risks in Eastern Ukraine by preparing, preventing and protecting civilian populations who are at risk of a major disaster.

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A Consortium led by: ACTED With: IMPACT Initiatives, RIGHT to PROTECTION in partnership with HIAS, DANISH RED CROSS, AUSTRIAN RED CROSS

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Anthropogenic Hazards

Vuglehiska TPS damaged by shelling, 27.07.2015
By RBC.ua

Fire damage at Bakhmut Agrarian Union, 03.08.2018
By State Emergency Service of Ukraine (SESU)

Detection of an explosive object in Myronivske, on the territory of Myronivska heating power plant (HPP), 03.08.2018
By SESU

Bakhmut Raion is located in the northern part of Donetska Oblast in Eastern Ukraine. Bordering Luhanska Oblast to the north, the raion extends to within 5km of the contact line (CL). Currently, **16 potentially hazardous facilities are located within the raion itself, with a further 152 facilities within 25km.** Many of these facilities are located in the non-governmental controlled area (NGCA).

These hazardous facilities include mines, power stations, chemical and coke plants, water supply infrastructure, spoil tips, tailing dams and agricultural plants. The facilities pose both environmental and human risks due to hazardous substances, plus the threat of disruption due to conflict and poor maintenance. In addition, there are **>40 spoil tips in the raion and almost 700 within 25km,** particularly to the south and northeast, and extending into the NGCA.

The settlements of Luhanske, Myronivskyi and Vozdvyzhenka are the most exposed to hazardous facilities. These settlements are all located very close to the CL, putting them at high risk of conflict. For example, shelling at Vuglehiska Thermal Power Station (TPS) has led to fires and power access disruption on several occaisons since the start of the conflict, whilst shelling at industrial units such as Bakhmut Agrarian Union has led to environmental damage due to release of hazardous substances.

The coal sector accounts for >50% of Ukraine's greenhouse gas emissions and is a major source of air pollution in the region. Frequent overage of maximum permitted concentration (MPC) is registered; in particular for aerosols, nitrogen dioxide and sulfur dioxide. According to the World Health Organisation (WHO, 2020), chronic exposure to air pollution increases mortality from stroke, heart disease, lung cancer and acute respiratory infections.

Zaitseve witnessed the greatest number of conflict incidents from July 2019-June 2020 (265), followed by Dolomitne (NGCA) and Novoluhanske, both with >200 incidents. In addition to being an anthropogenic hazard, conflict is considered a trigger for other hazards, increasing risk posed by hazardous facilities, and impacting societies' coping capacity.

Wildfires and urban fires are common in the raion. **Bakhmut recorded the highest number of satellite-detected fires from 2001-2019 (128),** followed by Luhanske, Zaitseve and Soledar, with around 70 each.

Significant wildfire fuel was identified in proximity to these

Natural Hazards

Wildfires in grassland and agricultural land near the Kreidova Flora Nature Reserve, 26.07.2020
By S.Limanskij

Water supply system damage due to shelling, 22.07.2020
By United Nations Children's Fund (UNICEF)

Vuglehiska TPS in Svitlodars, 7.07.2010
By Wikipedia

settlements through satellite land cover detection. This is a concern given the number of conflict incidents in the area, which can be a trigger for wildfires, as mentioned previously.

According to The Armed Conflict Location & Event Data Project (ACLED) database, **five settlements have been affected by landmine explosions since 2017**, including Luhanske, Zaitseve and Svitlodarsk. Landmines are considered both a potential trigger for wildfires and as an indicator of limited coping capacity for communities, since they complicate emergency service access. Snow, heavy rains, flooding and smog were mentioned in secondary data review as natural factors increasing mine explosion risk with the absence of visible warning signs.

During cold waves and heat waves, ongoing conflict can lead to disruption of utility networks. If affected, the coping capacity of the population is significantly reduced, increasing their risk to these hazards. Between 2000 and 2019, **Zelenopilia, Pylypchatyne, Volodymyrivka and Olenivka each experienced 30+ days/year on average where temperatures exceeded +37°C and are therefore most at risk from heat waves.** As for cold waves, **Platonivka experienced an average of 24 days where temperatures fell below -15°C**, whilst many other settlements in the north experienced >20 days, making this area the most at-risk from cold waves.

Rural settlements were found to be more vulnerable to natural and anthropogenic hazards than urban areas, with urban areas >5km from CL having the lowest vulnerability. Novoluhanske meanwhile had the highest vulnerability (a rural settlement <5km from the CL). Predictably, **settlements closer to the CL experienced more conflict events, with Zaitseve recording 24% of all incidents.** Vulnerability was calculated based on susceptibility and coping capacity, accounting for factors such as unemployment, dependency and service access. It was found that **urban settlements <5km from the CL had the highest proportion of population with disabilities and the highest proportion of vulnerable head of households**.

In addition, **distances to key services can affect coping capacity** and it was found that rural settlements <5km from the CL generally had to travel further to reach a primary health care facility or social facility, whilst urban settlements less than 5km from the CL had further to travel to an education facility in general*.

* Data for this overview was gathered from different secondary sources. For more details, please see the methodology section here

INTRODUCTION

Background

Ukraine has been affected by conflict since 2014, and civilians continue to be negatively impacted by the crisis. Since April 2014, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) reported more than 3000 civilians have died, 9000 have been injured and up to 1.5 million have been internally displaced. Today, despite the Minsk agreements, the conflict continues to affect 5.2 million people, of whom 3.5 million are in urgent need of protection and humanitarian assistance (UNOCHA 2019).

In parallel, the population remains vulnerable to pre-existing natural and anthropogenic hazards such as extreme weather and hazardous critical infrastructure failure. Systems to cope with these hazards are becoming increasingly vulnerable due to lack of maintenance and continued conflict, limiting community capacity to prepare, prevent, and protect.

Populations living closest to the CL also face conflict-related hazards including: regular shelling; high mine and unexploded ordnance (UXO) contamination; and frequent utility cuts, which are particularly dangerous in harsh winters. Moreover, conflict exacerbates risks posed by pre-existing anthropogenic hazards, both directly through shelling of critical infrastructure and indirectly due to poor maintenance, or abandonment.

The conflict also exacerbates the risks of natural hazards. Eastern Ukraine has a humid continental climate characterised by large seasonal temperature fluctuations, with hot summers and cold winters.

Extreme weather events are not uncommon in this region. Severe winters coupled with poor or damaged shelter infrastructure or heating services can increase the risk of hypothermia and carbon monoxide poisoning. In 2006, 60,000 residents in the city of Alchevsk were left without heating for weeks due to a heating system failure during a severe cold spell, resulting in the evacuation of all children until heating was restored (2006, February 11, *The Guardian*). This scenario was repeated to a lesser extent in February 2017 when electricity and water infrastructure in Avdiivka was extensively damaged and led to a significant decrease in capacity of the heating system for several weeks, prompting local authorities and humanitarian actors to set up communal heating points (2017, February 1, *UNICEF press release*).

During the summer, heatwaves pose a threat of heat stroke, particularly to the elderly and other vulnerable populations. Due to the conflict, access to safe drinking water may be disrupted if water supplies are interrupted. In addition, Eastern Ukraine is susceptible to wildfires during hot summer months, and conflict-related explosions only increase the likelihood of wildfires due to proximity to the CL. In 2010, the Luhansk region experienced a 24-day heatwave which triggered hundreds of wildfires.

This Area Based Risk Assessment (ABRA) aims to highlight the multiple hazards that settlements are exposed to, both natural and anthropogenic, and their risks to such hazards.

Overview of Assessed Area

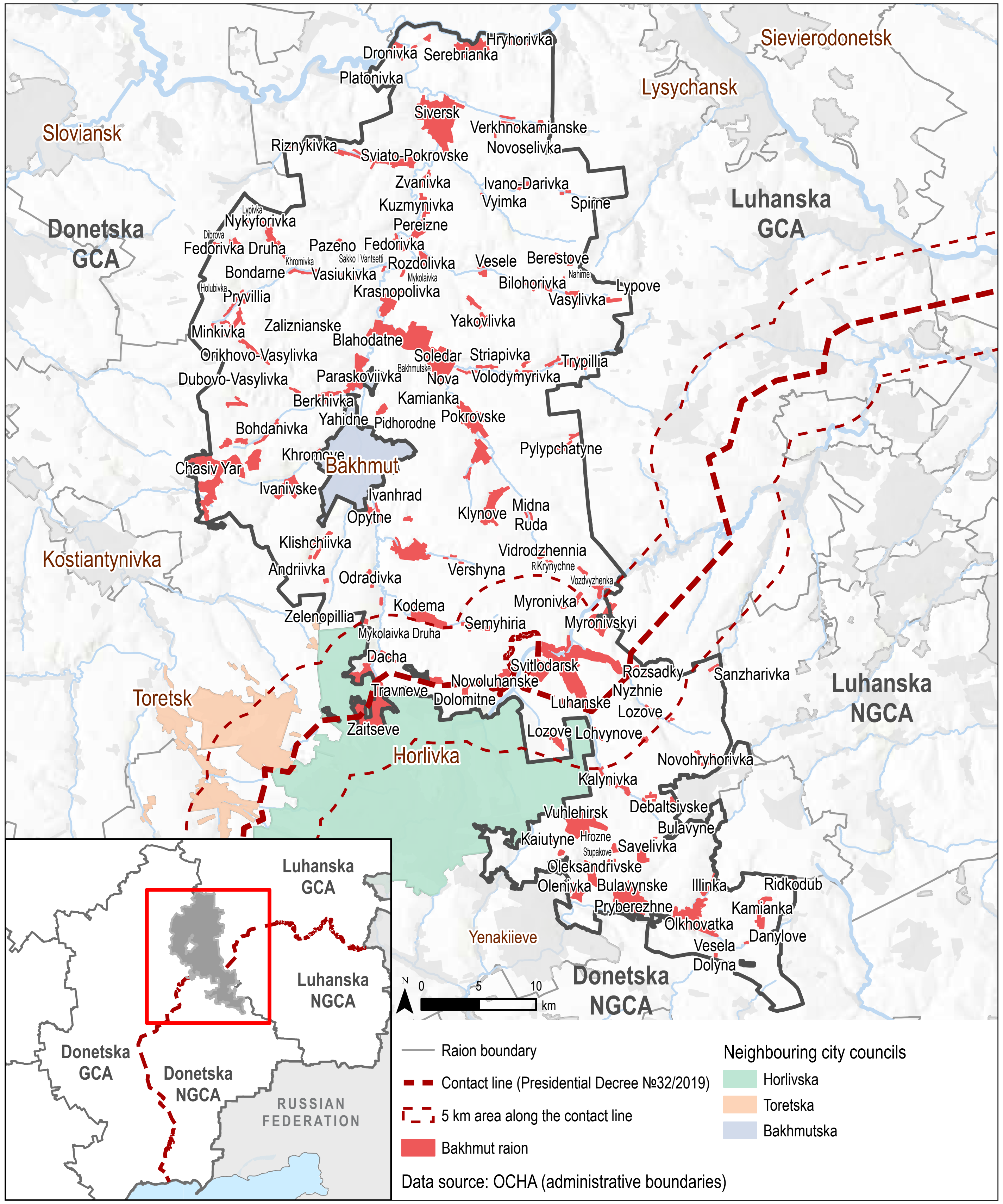
Bakhmut Raion is located in the northeast of Donetska Oblast, bordering Luhanska Oblast on the east. The area of Bakhmut Raion is 57,041.6ha, including 39,145.9ha of agricultural land (69%) and 2,137ha of forest (3.7%). The total population of Bakhmut Raion Government Controlled Area (GCA) is 45,026 (2020), whilst the administrative center of the raion is Bakhmut City, with an estimated population of 77,620 (CVA, 2018).

Bakhmut Raion includes 2 city councils (Svitlodarsk and Chasiv Yar), 2 urban-type councils (Myronivka and Luhanke), 3 village councils (Kalynivka, Kodema and Novoluhansk) and Zaitseve military-civil administration settlement located along the CL. Twenty-three settlements have been divided by the CL and are now located outside of the GCA.

According to the new prospective administrative plan, Bakhmut Raion includes 4 hromadas in the current area (Soledar, Siversk, Zvaniv and Bakhmut), as well as Toretsk Hromada. This ABRA is focused on Bakhmut area only (Bakhmut Raion GCA with Bakhmut City), whilst Toretsk area is covered in a separate ABRA.

Bakhmut Raion is one of the largest salt mining regions in Ukraine and there are 2 large operational salt deposits in the raion - Bakhmut and Novo-Karfagenne. In addition, there are clay deposits located near Chasiv Yar and a dolomite deposit for metallurgy near Siversk.

Overview map for Bakhmut Raion



METHODOLOGY

Methodology overview

This ABRA for Bakhmut Raion aims to develop a disaster risk profile by assessing the vulnerability and hazard exposure of communities. This is calculated using a risk equation, which assesses several indicators for hazard, exposure and vulnerability.

The ABRA analyses geospatial data on hazard exposure and community vulnerability to assess both natural and anthropogenic risks. It is conducted at the sub-regional level, and relies on both locally available data and global datasets. As of 2019, there is no centralized and functional platform for open geospatial data access for the region which allows disaster risk practitioners to seek information from a variety of sources.

Global datasets were also used during the assessment wherever possible. However, due to the localised area of the research, it was only possible to use datasets where the resolution was high enough to be appropriate.

Methodological approaches used within this work fall within the framework of The Global Facility for Disaster Reduction and Recovery (GFDRR), which is a global partnership that helps countries better understand and reduce their vulnerability to natural hazards and climate change (GFDRR, 2019).

For anthropogenic hazards, the Flash Environmental Assessment Tool (FEAT) 2.0 Pocket Guide was used to highlight human and environmental exposure to hazardous substances. The FEAT methodology was developed by the National Institute for Public Health and the Environment (RIVM) for the United Nations Environment Programme (UNEP) and UNOCHA. The FEAT Pocket Guide helps to support initial emergency actions and is seen as the entry point for more comprehensive expert assessments. The FEAT process can also be used in preparedness and community awareness efforts, which is the approach taken in this risk profile and the case studies.

The risk profile is based on available secondary data review and it was not possible to include all relevant indicators to determine risk. However, this risk analysis can serve as a useful indication of which settlements to prioritize for implementing risk reduction programmes, as well as evidence for further primary data collection to support DRR initiatives in areas of higher concern.

Risk

According to the United Nations Office for Disaster Risk Reduction (UNDRR), "disaster risk" is defined as "the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity." (UNDRR, 2019).

The World Risk Index, developed by the United Nations University's Institute for Environment and Human Security (UNU-EHS) and Alliance Development Helps (Bündnis Entwicklung Hilft), calculates disaster risk based on the exposure to key natural hazards as well as social vulnerability in the form of the population's susceptibility and their capacity for coping and adaptation (Bündnis Entwicklung Hilft, 2019). The ABRA takes this approach for assessing disaster risk, through assessing the multiplication of a settlement's hazard exposure and its vulnerability. The specific indicators and their weighting used in the risk calculation is further illustrated in figures 1.1 and 1.2.

It is important to highlight that the objective was to assess risk to the main hazards of the region, but is not inclusive of all natural and anthropogenic hazards. Inclusion was based on consultations with local authorities and 3P Consortium members and hazards exacerbated by the state of industrial objects and conflict dynamics throughout 2019 were prioritized.

Hazard

Hazards refer to the "probability of a potentially destructive phenomenon" (World Bank, 2014). The main hazards that were identified during consultations and secondary data review for Bakhmut Raion were: hazardous facilities from mine-related and chemical use, conflict, wildfires, and extreme temperature from cold waves and heat waves.

For each hazard, the approach was to identify potential exposure across Bakhmut Raion. Exposure is not limited to human population exposure, but also refers to 'the location, attributes and values of assets that are important to communities' (World Bank, 2014).

For hazardous facilities, community exposure is the only component considered in the risk equation, although it is important to further calculate the specific human health exposure and environmental exposure to soil and rivers as highlighted in the FEAT analysis (p.14 -15). However, this requires an individual assessment of each hazardous site, its substances and quantities present. This further analysis is recommended for sites that are close to the CL, or sites that have experienced disruptions in maintenance and operations.

As well as posing a direct hazard, conflict is a trigger for wildfires, and also as a variable that hinders coping capacity of the society when coupled with other hazards. Conflict as a hazard looks both at the exposure of the population to conflict incidents themselves, but also exposure of critical infrastructure such as the water network, gas and oil pipelines, and the electricity network.

Cold waves and heat waves are natural hazards posing a risk to the population of Bakhmut Raion. This risk can be exacerbated by conflict-related disruption to gas, electricity and water infrastructure, due to the impact on the coping capacity of the affected population.

Vulnerability

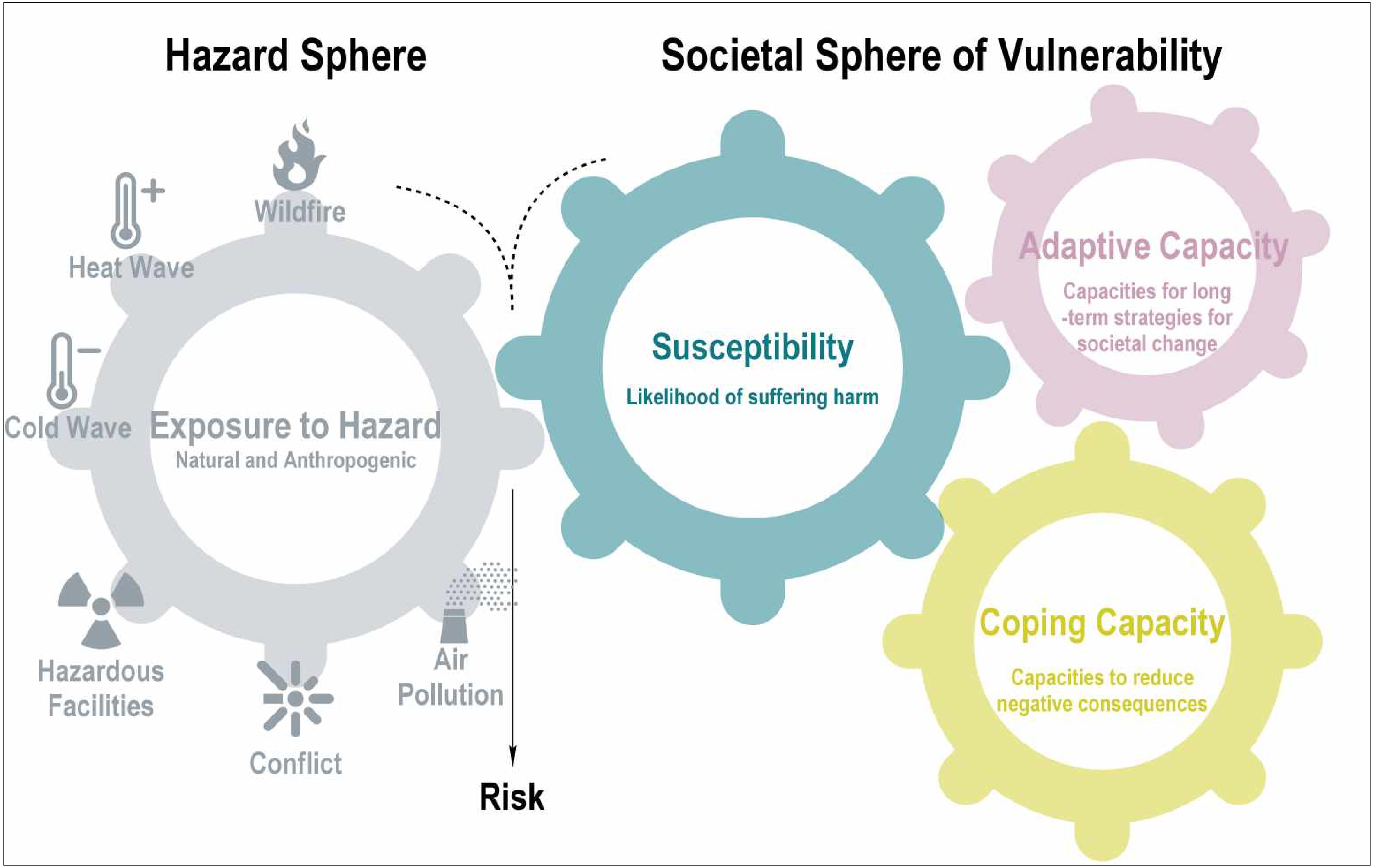
Vulnerability refers to the societal sphere, and its spatial interaction to a hazard is what defines disaster risk. Without societal exposure to a hazard, there is no risk, and where there is exposure to a hazard but low societal vulnerability, there is low risk. The societal sphere of vulnerability is a crucial component to defining disaster risk. The societal sphere of vulnerability is comprised of three components that interact with each other; namely these are susceptibility, coping capacity, and adaptive capacity as depicted in figure 1.1.

Susceptibility is the likelihood of suffering harm from one of the assessed hazards. Coping capacity refers to the capacities of the society to reduce negative consequences. Lastly, adaptive capacity, or capacity development are the societal capacities in place to develop and maintain long-term strategies to ensure social resilience to hazards and shocks, which may include various types of training, continuous efforts to develop institutions, political awareness, financial resources, technological systems and the wider enabling environment.

The most recent data available for Bakhmut Raion which assesses vulnerability was a 2018 household Capacity and Vulnerability Assessment (CVA) conducted by REACH (REACH, 2018). Several indicators from this CVA conducted on susceptibility and coping capacity were available to be extracted to calculate vulnerability to the hazards assessed and highlighted further in figure 1.2. Data for adaptive capacities was not accessible, and therefore not included in this analysis for the Bakhmut Raion risk profile. However, it is an important variable and indicators should be further researched to form a more comprehensive picture of societal vulnerability.

The household sample from the CVA for Bakhmut Raion was based on four stratas: urban settlements within 5km of the CL; urban settlements greater than 5km from the CL; rural settlements within 5km of the CL; and rural settlements greater than 5km from the CL. Therefore, societal vulnerability indicators will be representative not to the individual settlement but to the settlement classification.

Figure 1.1 Risk Diagram



Hazard Exposure

The exposure of communities to these multiple hazards is something that needs to be better understood at the local level with proper response and contingency plans in place. This analysis hopes to raise awareness to hazard exposure at the local level.

Natural Hazards

Indicator 1.1: Wildfire

- Proximity of settlement to fuel (forest landcover); number of satellite-detected fires (2000-2019) from NASA's Fire Information for Resource Management System (FIRMS) which includes all fires in urban, agricultural and forest land cover types; the number of landmine areas still contaminated and number of conflict incidents in 2019 within a settlement or within 2km of a settlement, as a trigger for more frequent wildfires.

Indicator 1.2: Heat wave

- Percent of days settlement experiences land cover temperature of +37°C or higher during June, July and August (2000-2019) using remote sensing methodologies from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) Land Surface Temperature and Emissivity (MOD11).

Indicator 1.3: Cold wave

- Percent of days settlement experiences land cover temperature below -15°C during December, January and February (2000-2019) using remote sensing methodologies from MODIS MOD11.

Anthropogenic Hazards

Indicator 2.1: Hazardous Facilities

- Number of hazardous facilities within a settlement or within 2km of settlement, using geospatial data from the Donbas Environment Information System, and the Water, Sanitation and Hygiene (WASH) Cluster.

Indicator 2.2: Conflict

- Number of conflict incidents within a settlement or within 2km of a settlement. Conflict incidents collected by the International NGO Safety Organization (INSO) for the period of 2019 were used for analysis.

Indicator 2.3: Air pollution

- 6-month averaged (January-June 2020) satellite data from Sentinel-5P on NO_2, SO_2, aerosols.

Susceptibility

Population groups that are more susceptible to a hazard have increased vulnerability. Susceptibility is driven by many components but two components the REACH CVA provides data on that influence susceptibility are dependencies and economic capacity.

Dependency

Indicator 3.1: Households with high number of children

- Relevance: Children are more susceptible to hazards as they have higher dependency on others and may be unable to protect themselves or evacuate if necessary. Children are particularly sensitive to changes in climate, because their developing systems limit their ability to adapt to extreme heat and cold. Therefore, households with more children are more susceptible.
- Indicator: Proportion of households with three or more children

Indicator 3.2: The Elderly

- Relevance: Similarly to children, the elderly are more susceptible to hazards as they have higher dependency on others and may be unable to protect themselves or evacuate if necessary.
- Indicator: Proportion of the population 65 years or older

Indicator 3.3: Disability

- Relevance: Apart from the potential physical inability to evacuate during a disaster, their reliance upon others to ensure their evacuation to safety may involve reliance upon public services.
- Indicator: Proportion of the population with one or more disability

Indicator 3.4: Heads of Households (HoH) who are widows, single parents, or single female HoH

- Relevance: Single female HoHs, widows, and single parents are found to be disproportionately affected by disasters due to their compounded vulnerabilities and thus this group is considered more susceptible to the shocks of hazards.
- Indicator: Proportion of HoHs who are either a widow, a single parent, or single female HoH

Indicator 3.5: Farmers

- Relevance: Farmers are included here as a susceptible group because their livelihood is heavily dependent on agricultural land and the environment, something that is extremely exposed to hazards arising from conflict, hazardous chemical facilities, wildfires, and extreme temperature.
- Indicator: Proportion of the population whose livelihood is agriculture

Economic Capacity

Indicator 4.1: The Unemployed

- Relevance: Unemployment hinders the economic capacity for preparedness mitigation measures as well as the financial ability to cope during and after the shock of the hazard.
- Indicator: Proportion of the population that is unemployed

Indicator 4.2: Pensioners

- Relevance: Those whose economic capacity is dependent on access to their pensions are more susceptible due to the low financial amount and benefits received.
- Indicator: Proportion of the population who are pensioners.

Coping Capacity

The ability of a population to cope after a hazard occurs is crucial in reducing negative consequences and influences one's vulnerability and risk level to a hazard. The REACH CVA and SESU provide data on distances to key services. Data is also available on preparedness awareness, conflict incidents, and displacement status. These are all factors that drive coping capacity.

Distance to Services

- Relevance: Distance to services affect coping capacity, both in terms of accessing important networks of information regarding preparedness and early warning, but also as a response mechanism during the shock of a hazard

Indicator 5.1: Distance to health care facility

- Indicator: Proportion of population that reports greater than 30 minutes traveling time to a primary health care facility

Indicator 5.2: Distance to social services facility

- Indicator: Proportion of population that reports greater than 20km traveling distance to a social services facility

Indicator 5.3: Distance to education facility

- Indicator: Proportion of population that reports greater than 30 minutes traveling time to an education facility

Indicator 5.4: Distance from a State Emergency Services of Ukraine (SESU) unit

- Indicator: Settlement distance from nearest SESU response unit location

Indicator 6.1: Bomb shelter awareness

- Relevance: Bomb shelters are common in Eastern Ukraine and can provide temporary safe shelter during the shocks of the hazard
- Indicator: Proportion of the population who are not aware of the nearest bomb shelter

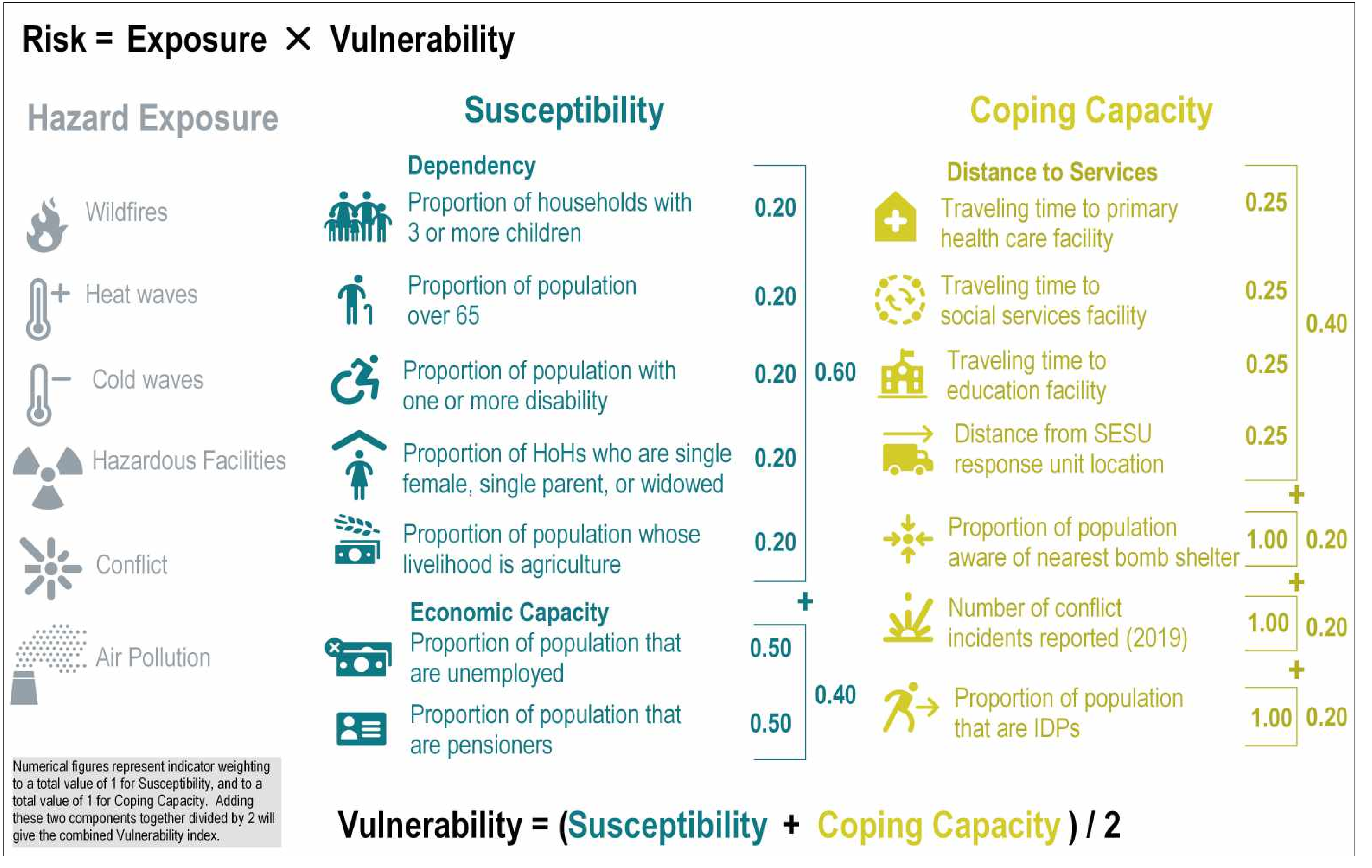
Indicator 7.1: Conflict

- Relevance: Conflict is both relevant as a direct hazard but also something that hinders the coping capacity of communities to other natural and anthropogenic hazards.
- Indicator: Number of conflict incidents reported by INSO in a settlement or within a 2km radius.

Indicator 8.1: IDPs

- Relevance: IDPs depending on their current shelter status are usually more susceptible to the exposure of hazard, but also internally displaced persons (IDPs) lack coping capacities due to limited social networks in their new place of residence.
- Indicator: Proportion of the population that are IDPs

Figure 1.2 Risk Indicator Diagram



HAZARD - WILDFIRES

Hazard Description and Findings

Wildfire and urban fires are a major hazard to the environment, populations and infrastructure in Bakhmut. Triggered by both natural and anthropogenic activities, they can lead to direct (severe burn, smoke inhalation) and indirect mortality, and destroy large swathes of natural habitat and manmade infrastructure. According to the Intergovernmental Panel on Climate Change (IPCC), rising global temperatures and an increase in the frequency and severity of heatwaves is causing the number of fires occurring in the region to grow each year (IPCC, 2018).

This review consists of fire data in Bakhmut Raion from two sources: satellite data from the National Aeronautics and Space Administration (NASA) Fire Information for Resource Management System (FIRMS)[1] for the years of 2001-2019 and data provided by the State Emergency Service of Ukraine in Donetska Oblast for the years 2015-2018 (SESU, 2019).

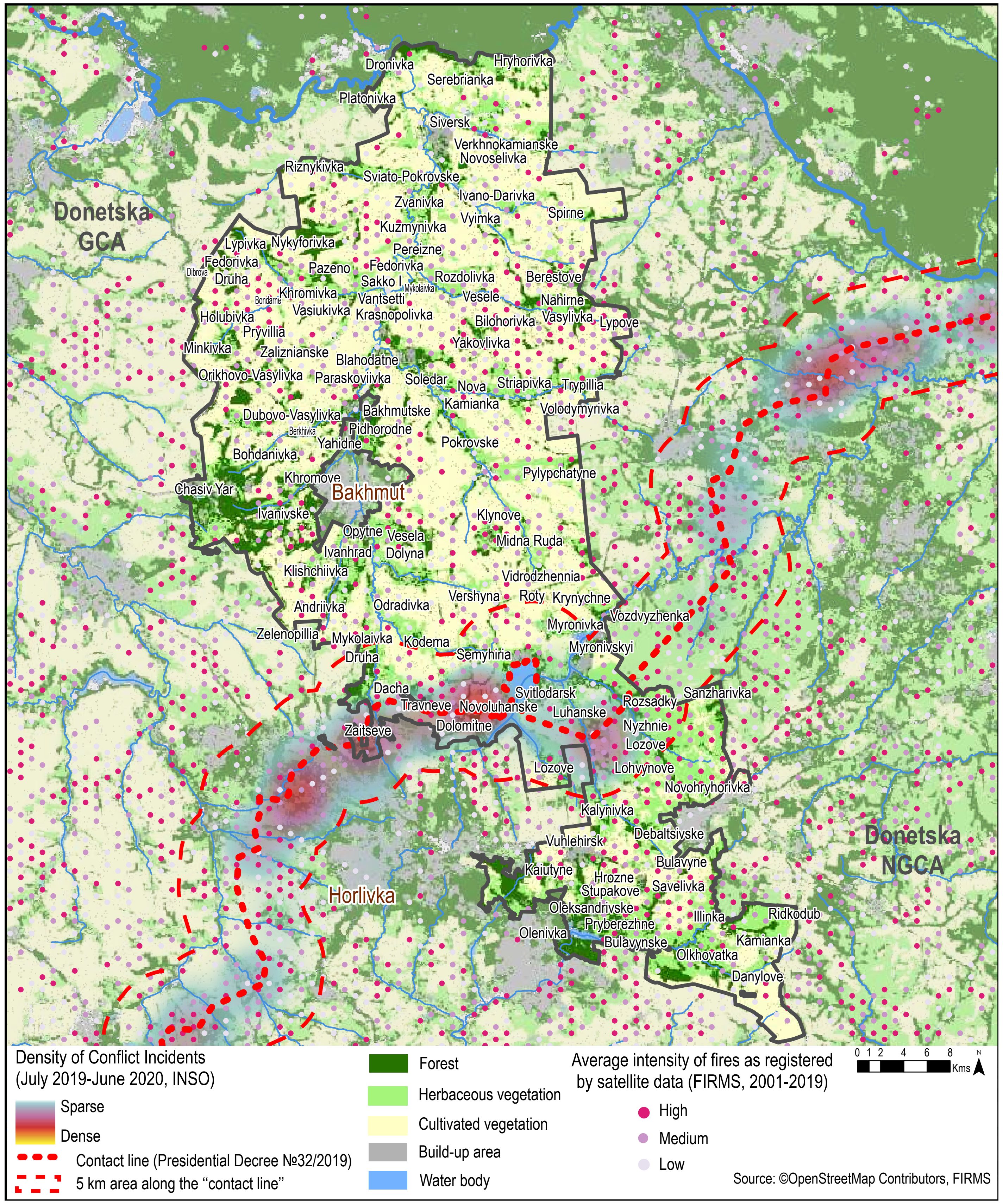
According to FIRMS satellite data, the highest fire frequency was observed near Luhanske, Soledar, Riznykivka, Siversk, Zaitseve, Kalynivka and Pokrovske. Parts of these settlements are located along the CL in an area of high conflict density, which may have caused many of the detected fire events.

Along with conflict incidents themselves, landmine contamination is a potential trigger for wildfires. Landmine fields have been registered[2] near 5 settlements - Kodema, Riznykivka, Dacha, Semyhiria and Sviato-Pokrovske, whilst landmine explosions have been recorded by ACLED within 2km of Luhanske, Novoluhanske, Svitlodarsk, Rozsadky and Zaitseve. ACLED data on landmine explosions was included in the wildfire indicator component. According to SESU data, most of the fire events occurred in Bakhmut, Chasiv Yar, Soledar, Siversk, Olenivka and Luhanske.

1) FIRMS dataset is based on satellite observations by MODIS and includes data regarding the time, location, and intensity of fires. Dataset excludes fires on industrial land use to avoid conflating the numbers with heat signatures related to industrial processes.

2) Map of mine-contaminated areas by the Ministry of Defence of Ukraine (https://mod-ukr.imsma-core.org).

Map 1.1 Average Frequency and Intensity of Fires



Map 1.2 Regional Overview of Forest Land Cover

Many satellite-detected fire events in the area are located in agricultural land. This might be a result of the common agricultural practice of stubble burning to prepare a field for sowing, which may lead to the uncontrolled spread of fire, but also leads to soil moisture loss, which is already limited.

Key takeaways

1. There is a need for an alert system (to be developed) and rapid fire monitoring services, with the increase in wildfire frequency due to climate change.

2. Restoration of forest belts, fire-control measures in the forest areas and firebreak implementation between areas exposed to continuing conflict incidents.

3. Control of agricultural stubble burning.

4. Landmine field detection, marking and installation of warning signs followed by de-mining activities are needed.

FIRES (all classifications): STATE EMERGENCY SERVICES OF UKRAINE DATA

Map 1.3 SESU trips on report of fire

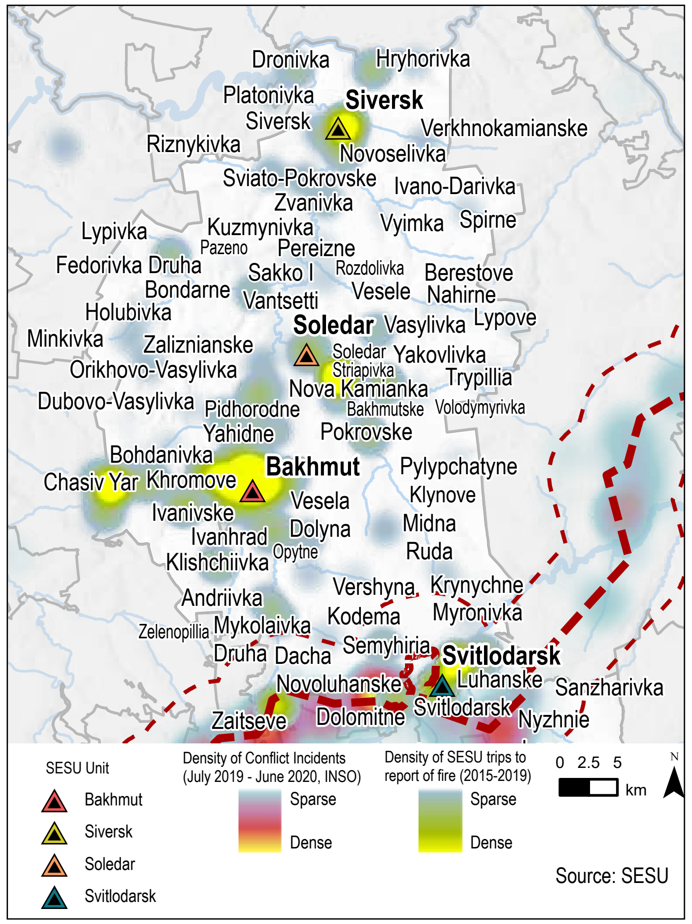
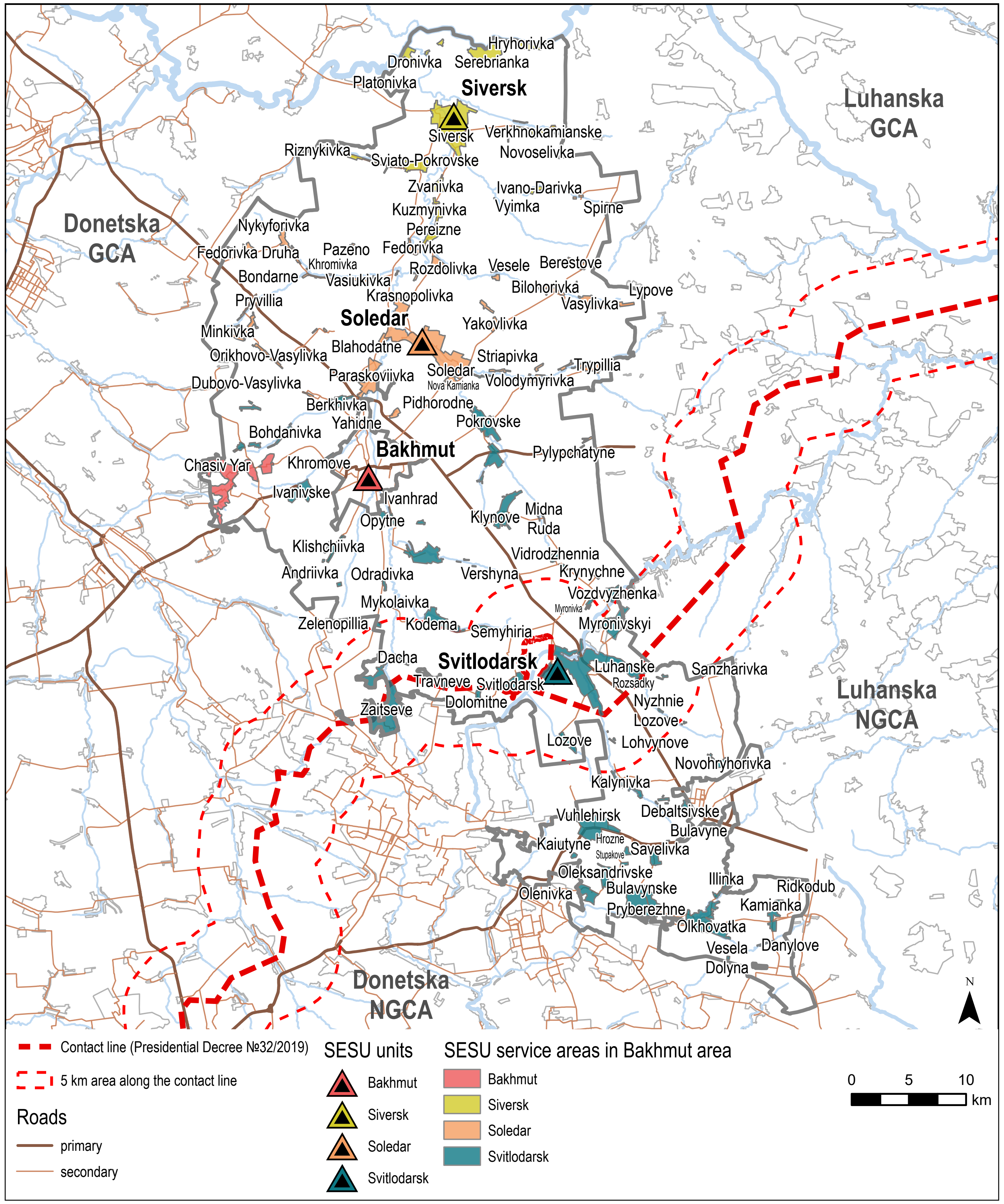


Table 1.1 Annual Number of SESU Trips to Report of Fires

Settlement	2015	2016	2017	2018	Total
Bakhmut	155	157	182	134	628
Chasiv Yar	50	57	45	67	219
Soledar	32	45	53	41	171
Siversk	27	33	56	34	150
Olenivka	29	34	21	61	145
Luhanske	24	29	39	30	122
Zaitseve	13	26	50	30	119
Svitlodarsk	7	12	15	26	60
Khromove	6	19	14	10	49
Paraskoviivka	5	12	8	8	33
Ivanivske	3	10	8	9	30
Novoluhanske	3	3	14	10	30

Map 1.4 SESU Unit Location and Service Area for Bakhmut Raion



Map 1.6 Regional Overview of Average Annual Number of SESU Trips to Reports of Fire

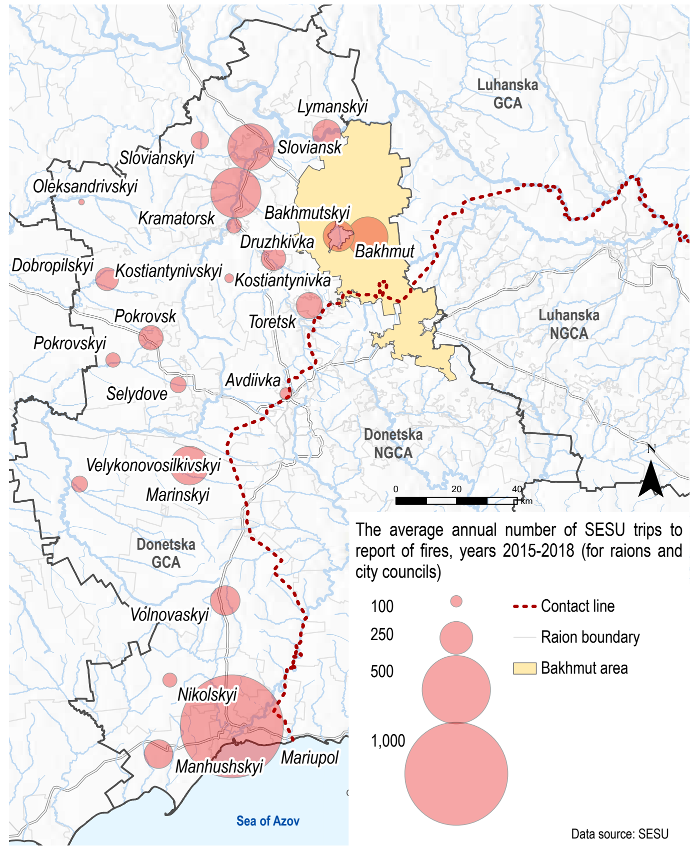
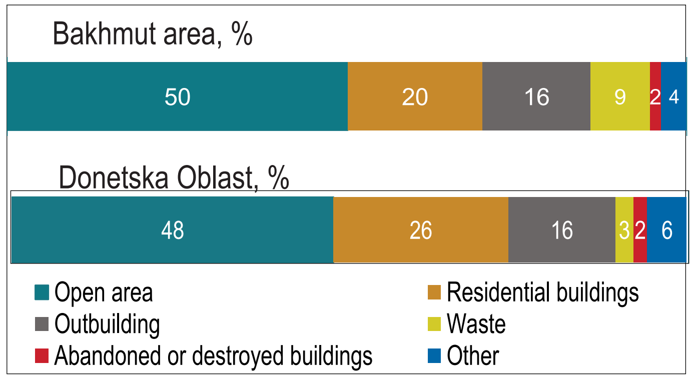


Table 1.2 Most Common Locations of Fires

Affected Area	2015	2016	2017	2018	Total
Open area	186	305	287	312	1090
Residential buildings	92	83	152	103	430
Outbuilding	76	75	113	82	346
Waste	43	46	63	38	190
Abandoned or destroyed buildings	8	7	14	6	35
Motor transport	10	7	10	8	35



Hazard Description

Prolonged periods of extreme heat are referred to as heatwaves (IFRC, 2011). Whilst the exact definition varies by country, heatwaves are usually defined by a signifcant and prolonged deviation from the long-term average temperature. They have a significant impact on society, increasing both mortality and morbidity, as well as increasing strain on infrastructure and ecosystems.

Heatwaves are a leading cause of disaster-related deaths. The 2010 northern hemisphere heatwave led to > 15,000 deaths due to heat stroke and dehydration, particularly affecting susceptible groups. The frequency and severity of heatwaves are increasing (IPCC, 2019) and will become increasingly difficult to address.

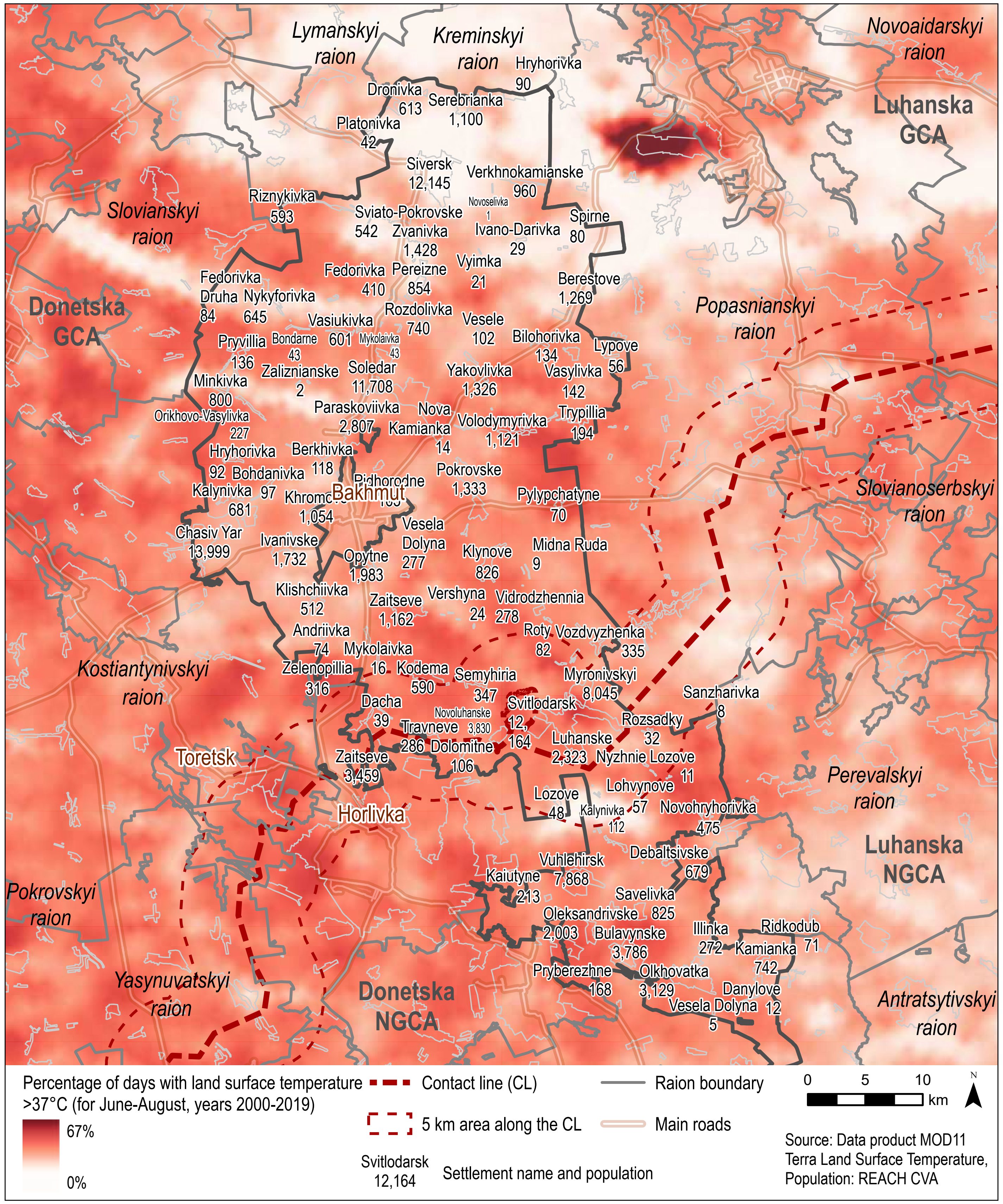
Data on abnormally high temperatures in Bakhmut Raion and adjacent territories was acquired from MODIS MOD11[3] (Wan, Z., Hook, S., Hulley, G., 2015), using temperature observations in June, July and August. +37°C was determined as the lower limit for abnormally high temperatures, one standard deviation above the observed mean during the study period (2000-2019).

Several heatwave hotspots are visible on map 2.1, near Olenivka, Bakhmutske, Kodema, Svitlodarsk, Holubivka, Nyzhnie Lozove and Vesela Dolyna. Half of these settlements are within 5-10 km from the CL. The northen part of the raion, close to Siverskyi Donetsk River and the forested area are less exposed.

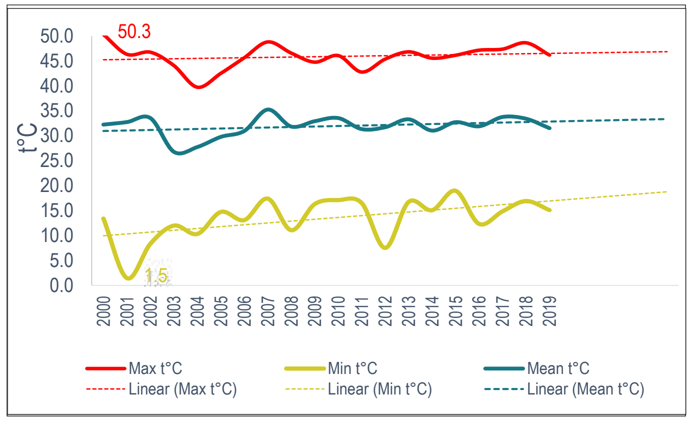
As indicated in Graph 2.1, the highest land surface temperatures (+50.3°C) were observed in June 2000, June 2007(+48.8°C) and July 2018 (+48.7°C). The 20-year-averaged land surface temperature during the summer is +31.9°C. In the last 10 years, a continuous gradual increase of maximum temperature has been observed (with a prognosis of +1°C in the next 5 years) and a more rapid increase of minimum land surface temperature (with a prognosis of +3.5°C in the next 5 years according to linear trend).

3) Land Surface Temperature (LST) and emissivity daily data are estimated from land cover types, atmospheric column water vapor and lower boundary air surface temperature are separated into tractable sub-ranges for optimal retrieval.

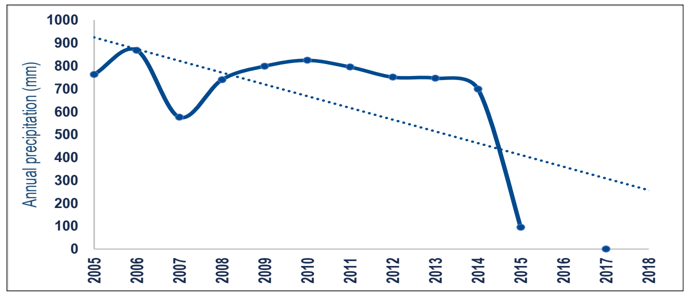
Map 2.1 Percentage of Days in Summer Season with Temperature > 37°C



Graph 2.1 Mean Temperature in Summer Months



Graph 2.2 Annual Precipitation



Heat waves and droughts are often interlinked and extreme temperatures can exacerbate drought impacts. Graph 2.2 shows annual precipitation at Bakhmut Weather Station. A clear decline is visible recently, especially in 2015, and 2017, when no rainfall was recorded. Drought conditions can dry out vegetation, providing ample fuel for wildfires (Centre For Climate and Energy Solutions, 2019)

The use of land surface temperature products such as MODIS help authorities identify areas and periods in which abnormally high temperatures may affect resident health and can support preparedness and response mechanisms. Coupled with data on vulnerable groups, particularly those who are more susceptible to heatwaves, authorities can better target risk reduction initiatives within communities that see more frequent exposure to abnormally high temperatures.

Key takeaways

1. Inform community and vulnerable groups on WHO recommended practices during heat-waves.
2. Ensure warning system is in place to communicate heat forecasts.

Hazard Description

According to the International Federation of Red Cross and Red Crescent Societies (IFRC, 2018), extreme cold or cold waves are weather conditions defined by either a rapid drop in air temperature or a sustained period of excessively cold weather (IFRC, 2018). Severe cold is a threat to human health as prolonged exposure can lead to hypothermia, frostbite and cardiac arrests which tend to lead to increased mortality (Wang, 2016). Deterioration in transport conditions also leads to higher instance of road accidents (Hayat et al, 2013) and affects utility networks such as water and heating systems (Anel et al, 2017). In addition, extreme cold severely damages crops, affecting food production and livelihoods (Massey, 2018).

Ukraine experienced two cold waves in 2006 and 2017. According to the IFRC (IFRC, 2006), 884 people died as a result of the extremely low temperatures. Cold waves most commonly cause fatalities due to hypothermia, but also carbon monoxide poisoning in attempts to heat shelters.

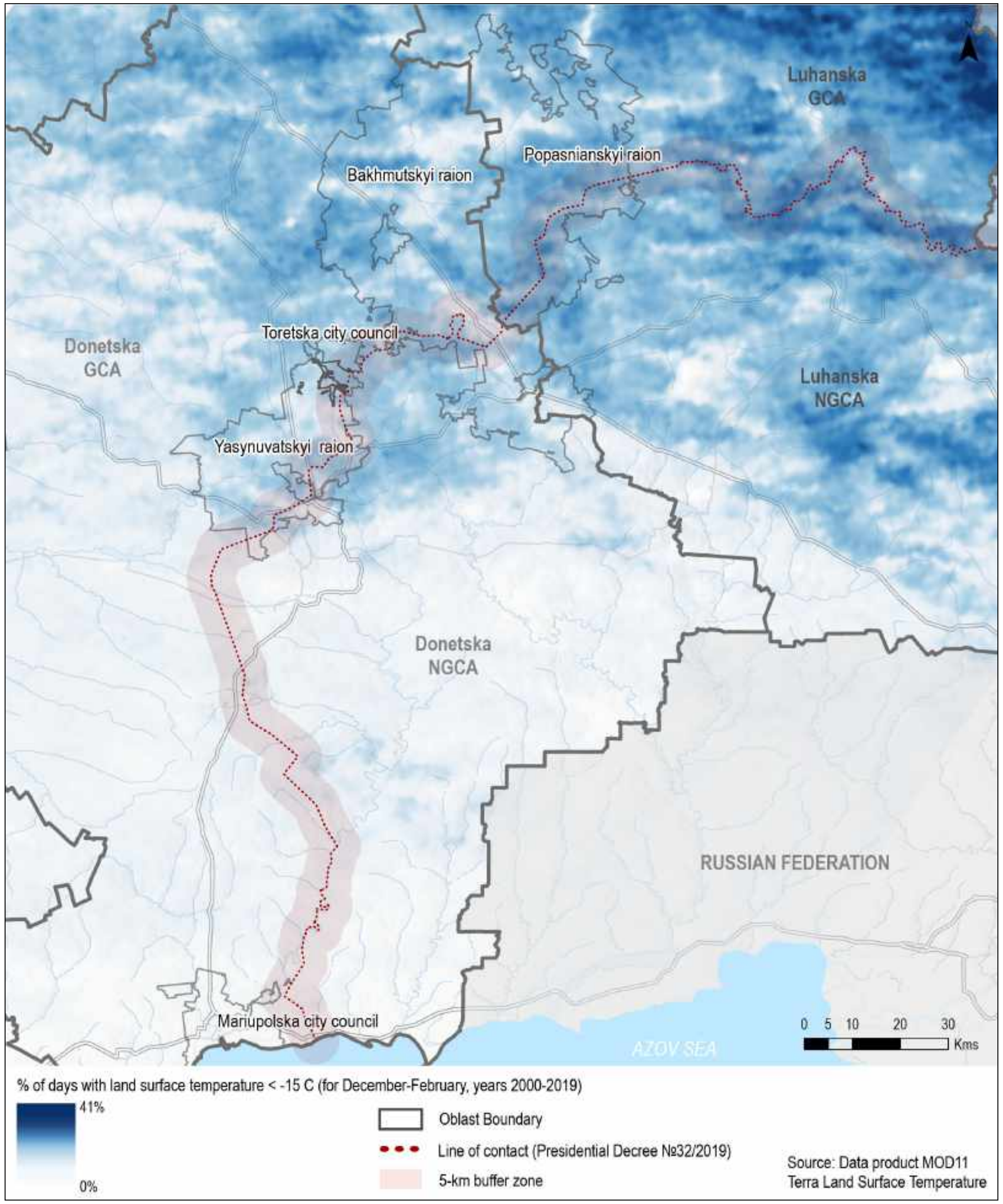
Information about abnormally low temperatures in Bakhmut Raion and adjacent territories was calculated using MOD11[4], based on temperature observations in December, January and February between 2000 and 2019. Utilizing data from 835 satellite acquisitions, Map 3.1 shows the percentage of days with temperatures below -15°C during the study period.

Higher frequency of days with extreme low temperatures can be observed around most of Bakhmut Raion, especially the western part of the raion. Compared to other regions along the CL, Bakhmut and Luhansk Oblast experience much higher frequencies compared to neighbouring regions in Donetsk Oblast.

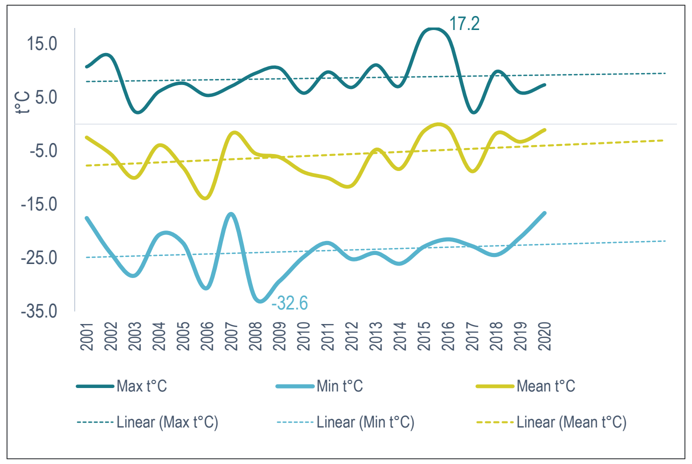
The lowest temperature (up to -32.6°C) was observed in winter 2008 and -30.6°C in January 2006. The highest land surface temperatures in winter (+17.2°C) were observed in February 2015. The 20-year-averaged land surface temperature during the winter is -5.9°C.

4) The Land Surface Temperature (LST) and Emissivity daily data are estimated from land cover types.

Map 3.1 Percentage of Days in Season with Temperature < -15C



Graph 3.1 Mean, Minimum and Maximum Temperature in Winter 2000 - 2019 (December-February)



In the last 10 years, a continuous gradual increase in mean, and minimum winter land surface temperatures is observed.

While a range of infrastructure can be affected, the most exposed to low temperatures are water and heating infrastructures. Freezing of water pipes, damage to power lines, and failure of heating systems can cause lasting damage to water access, power, and heating supplies, putting populations at further risk.

Key takeaways

1. Ensure vulnerable groups in areas that experience the most extreme weather can access financial support to cover basic expenses for heating.
2. Increase awareness of initiatives for communal hotspot locations in the case of complete failure of heating supply.
1. Increase awareness on best practices to keep shelters warm and safely heat shelters during disruption to conventional heating supply.
2. Local responders to identify the most susceptible population groups in the community, especially those that may require assistance, and develop contingency plans for this population (the elderly, those with disabilities or young children).

Hazard Description

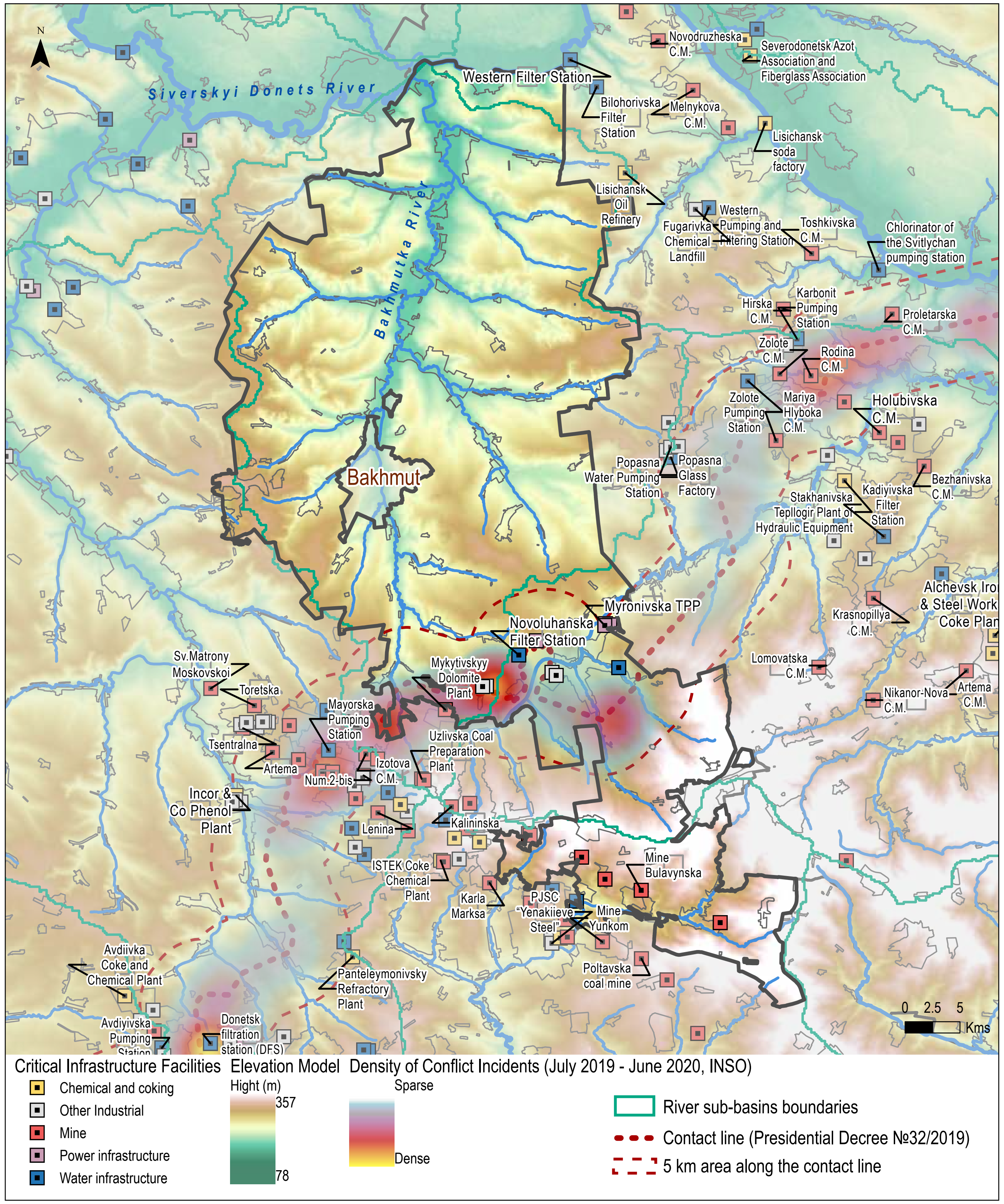
Based on review of the Humanitarian Needs Overview (HNO) and the Donbas Environment Information System (DEIS) developed by the Organization for Security and Cooperation in Europe (OSCE) as part of the Environmental Impact Assessment in Eastern Ukraine (commissioned by the Ministry of Ecology and Natural Resources of Ukraine), there are an estimated 16 hazardous facilities in the raion.

These sites include chemical and coke industries, coal mining, water supply infrastructure, machine building, and metallurgy. These facilities are considered to pose both an environmental and human risk due to the hazardous substances present and threat of disruptions or malfunctions due to the conflict.

Table 4.1 Hazardous Facilities within 1000m of Conflict Incidents Reported During 2019-2020 (INSO)

Facility name	Distance to settlement in Bakhmut area	2019	2020 Jan-June
Haharina Coal Mine	Zaitseve (5km)	160	49
Mykytivskyy Dolomite Plant	Travneve (1km)	62	38
Mayorska Pumping Station	Zaitseve (3km)	54	38
Horlivska Coal Preparation Plant	Zaitseve (5km)	6	20
Bakhmut Agrarian Union	Dolomitne (1km)	18	3
Popasna Water Pumping Station	Pylypchatyne (7km)	10	3
Popasna Glass Factory	Pylypchatyne (7km)	10	3
Popasna State Enterprise Locomotive Depot	Pylypchatyne (8km)	10	3
Coal Experimental Feed Mill	Dolomitne (1km)	26	2
Horlivka Meat-packing Plant	Zaitseve (5km)	2	2
Izotova Coal Mine	Zaitseve (2km)	3	1
Pervomayske Heat and Power Company	Lypove (14km)	1	1
Mykytivska Coal Preparation Plant	Zaitseve (2km)	18	1

Map 4.1 Major Hazardous Objects Location



Using the FEAT 2.0 Pocket Guide, key hazardous facilities within the region and their substances were cross-referenced to determine potential human and environmental exposure. This was provided in distances (km) based on low and high substance quantities (kg) to provide insight into a minimum and maximum exposure. The FEAT methodology was developed by the National Institute for Public Health and the Environment (RIVM) for UNEP and UNOCHA and is based on EU Directives on hazardous substances. Harmonization of Ukrainian legislation with European regulations on handling hazardous substances is one of the priorities in European integration in the field of health and environmental protection.

1. COAL POWER STATIONS

The coal sector accounts for more than 50% of Ukraine's greenhouse gas emissions (Energy Post, 2015) and coal-fired power stations in the region cause substantial air pollution, particularly due to sulfur dioxide and to a lesser extent, nitrogen oxide emissions. In total, the coal industry accounts for 80% of Ukraine's sulfur dioxide emissions (Energy Post, 2015).

Hazardous substance #1: Sulfur Dioxide (GHS classification: STOT SE1). Receptors: air, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (health)	> 5	Any quantity has an impact
Humans (lethal)	> 5	

- **Vuglegirska Thermal Power Station (TPS)**

On March 29th 2013, a fire caused by ignition of coal dust destroyed four turbines in Vuglegirska TPS. Since the beginning of the conflict in 2014, 11 shelling events were recorded near Vuglegirska TPS, which resulted in infrastructure damage and malfunction.

- **Myronivska Thermal Power Station (TPS)** is also located in the raion.

2. COAL MINING

Coal mining in the region poses many environmental and health risks and frequent explosions of methane gas have been reported. Meanwhile, many mines have been abandoned, posing a serious environmental hazard as mines can become flooded, contaminating groundwater and soil. High concentrations of radon and methane in the air present an air pollution issue and potential risk of explosions at both operational and abandoned mines.

Hazardous substance #1: Methane (GHS classification: Flammable, Flam Gas 1.)

Receptors: air, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (health)	0.2 - 0.3	1 million

Hazardous substance #2: waste from tailings (GHS classification: Toxic Liquid Acute Tox. 1, Aqu. Acute 1). Receptors: soil, groundwater, rivers, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (lethal)	1 - 5	20 - 1000
Humans (health)	> 5	20
Environment (soil)	2 - > 10	20 - 5000
Environment (river)	5 - > 10	20 - 1000

- **Bulavynska Coal Mine**

An accident occurred at this mine on September 2, 2020, where there was an explosion of coal and methane gas, necessitating the rescue of six miners.

- **Kondrativska Coal Mine**

Located just outside of Bakhmut Raion in neighboring Horlivska Raion. There is also a coal preparation plant associated with the mine.

- **Olkhovatska Coal Mine** is also located in the raion.

3. CHEMICAL AND COKE INDUSTRY

- **Concern Stirol Chemical Plant**

Hazardous substance #1: Ammonia (GHS Classification: Toxic Liquid Acute Tox. 2, Aquatic Chronic 2).

Receptors: air, humans, soil, groundwater and rivers.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (lethal)	0.3 - > 5	100 - 5000
Humans (health)	2 - > 5	100 - 5000
Environment (soil)	4.3 - 10	100 - 5000
Environment (river)	> 10	100

The plant was built in 1929 and produced organic fertilizers, ammonia, carbamide, granular ammonium nitrate, polystyrene, inorganic salts and organic resins. It is located in neighboring Horlivka Raion (NGCA), but hazardous substances could affect populations and the environment in Bakhmut Raion. On August 6, 2013, there was an accident that caused an ammonia release, leaving five dead and 20 injured.

The Horlivka-Odesa branch of the Toliati-Odesa ammonia pipeline entered operation in 1979 to transit liquid ammonia to the plant at Odesa Port. Since May 2014, the beginning of the conflict, the plant has suspended production and ammonia transportation due to security issues. However, there is still a risk that some amount of ammonia remains on the industrial site and along the pipeline which is crossing the CL (fig. 10.2).

- **Horlivka Coke and chemical Plant (ISTEK)**

Hazardous substance #1: industrial site contains **sulfur dioxide**, as well as hydrogen sulfide, hydrogen cyanide, nitrogen oxides, carbon monoxide, phenols, ammonia and benzopyrene (GHS Classification: Health hazard, STOT SE 1).

Receptors: air, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (health)	> 5	Any quantity has an impact
Humans (lethal)	> 5	

Hazardous substance #2: Waste from tailing containing phenols, ammonia and sulfuric acid.

Receptors: air, rivers, soils, groundwater, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (lethal)	> 5	Any quantity has a potential impact
Humans (health)	> 5	
Environment (soil)	> 10	
Environment (river)	> 10	

The plant is located in the NGCA. Work at these plants was terminated due to loss of control by management, but recent satellite images reveal the operations of blast furnaces.

4. WATER TREATMENT PLANTS (WATER FILTER STATIONS)

Hazardous substance #1: Chlorine (GHS Classification: Toxic Gas, Acute Tox. 1.)

Receptors: air, humans, critical infrastructure.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (lethal)	0.4 - 1.3	> 1 million
Humans (health)	2 - 5	10,000 - >million

Hazardous substance #2: Chlorine (GHS Classification: Toxic Liquid, Acute Tox. 1)

Receptors: soil, groundwater and rivers, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (lethal)	1-5	20- 1000
Humans (health)	> 5	20
Environment (soil)	2 - > 10	20 - 5000
Environment (river)	5 - > 10	20 - 1000

Other facilities in the raion include **Novoluhariska Filter Station** and **Skeleva Pumping Station.**

5. AGRICULTURE AND LIVESTOCK

- **Bakhmut Agrarian Union (est. 1997)**

Hazardous substance #1: Disinfecting agents, antibiotic and hormonal products, pesticides and animal Waste (GHS Classification: Aqu. Acute 1)

Receptors: soil, groundwater, rivers.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Environment (soil)	2.8 - > 10	100 - 5000
Environment (river)	> 10	100

Industrial pig farm located in Bakhmut Raion. Designed for a capacity of 40,000 pigs but hosting more than 90,000. The site is also located in a regular conflict hotspot with more than 18 recorded incidents.

Metabolic byproducts from the livestock can contaminate soil, groundwater and rivers. Based on the hydrology of the area, water contamination can affect Bakhmut and other water intake stations in Luhansk region.

6. OTHER MINES AND INDUSTRIAL PLANTS

- **Mykytivskyy Dolomite Plant**

Located just outside of the raion boundary in Horlivska, but environmental and health impacts could affect Bakhmut Raion.

Hazard substance #1: Methane (GHS classification: Flammable, Flam Gas 1.)

Receptors: air, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (health)	0.2 - 0.3	1 million

Hazardous substance #2: waste from tailings (GHS classification: Toxic Liquid Acute Tox 1, Aquatic Acute 1). Receptors: soil, groundwater, rivers, humans.

Exposure distance table:

Receptor	Distance (km)	Quantity (kg)
Humans (lethal)	1 - 5	20 - 1000
Humans (health)	> 5	20
Environment (soil)	2 - > 10	20 - 5000
Environment (river)	5 - > 10	20 - 1000

- **Soledar Salt Mines** are a vast collection of underground salt mines located northeast of Bakhmut in the settlement of Soledar. Although there are no major hazardous substances associated with the practice, water sources may become contaminated by salt-concentrated water discharge, whilst subsidence and ground instability is a major risk.
- **Ivanhrad Gypsum Quarry.** Mining of gypsum can present respiratory health issues due to dust inhalation, whilst tailing ponds may breach or cause the contamination of water sources. Subsidence and ground instability also pose a risk.

Facility Description

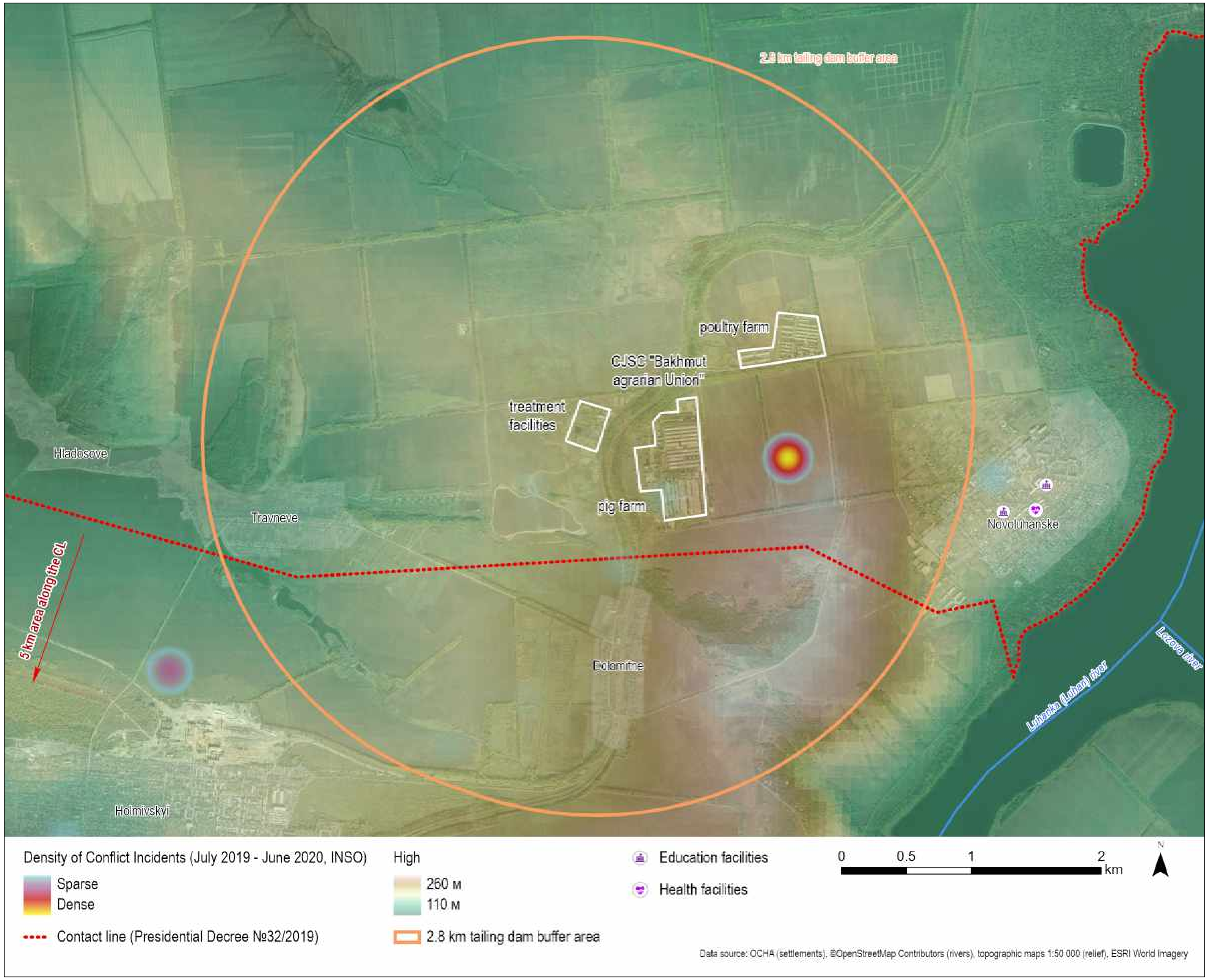
Public Join-Stock Company First Investment Bank (PJSC) Bakhmut Agrarian Union is an agro-industrial holding company, which includes enterprises of industrial pig, poultry and meat processing, crop and feed production. The company has a closed production cycle - from growing grain and industrial crops, producing its own mixed feed, beef, pork and poultry meat. The pig farm breeds more than 90,000 pigs.

The facility is located in Novoluhanske, around 5km from the CL. Eighteen conflict incidents were recorded close to the facility in 2019, as well as three in 2020 (January - June). Farm facilities were struck by shelling and infrastructure damage has been reported several times throughout this period. On May 13, 2017, fires caused by shelling destroyed 19 buildings. On June 16, 2017, damage to gas pipelines was reported due to shelling. The most recent infrastructure damage due to shelling was reported on August 20, 2019, indicating that the risk of spread of pollutants as a result of conflict remains.

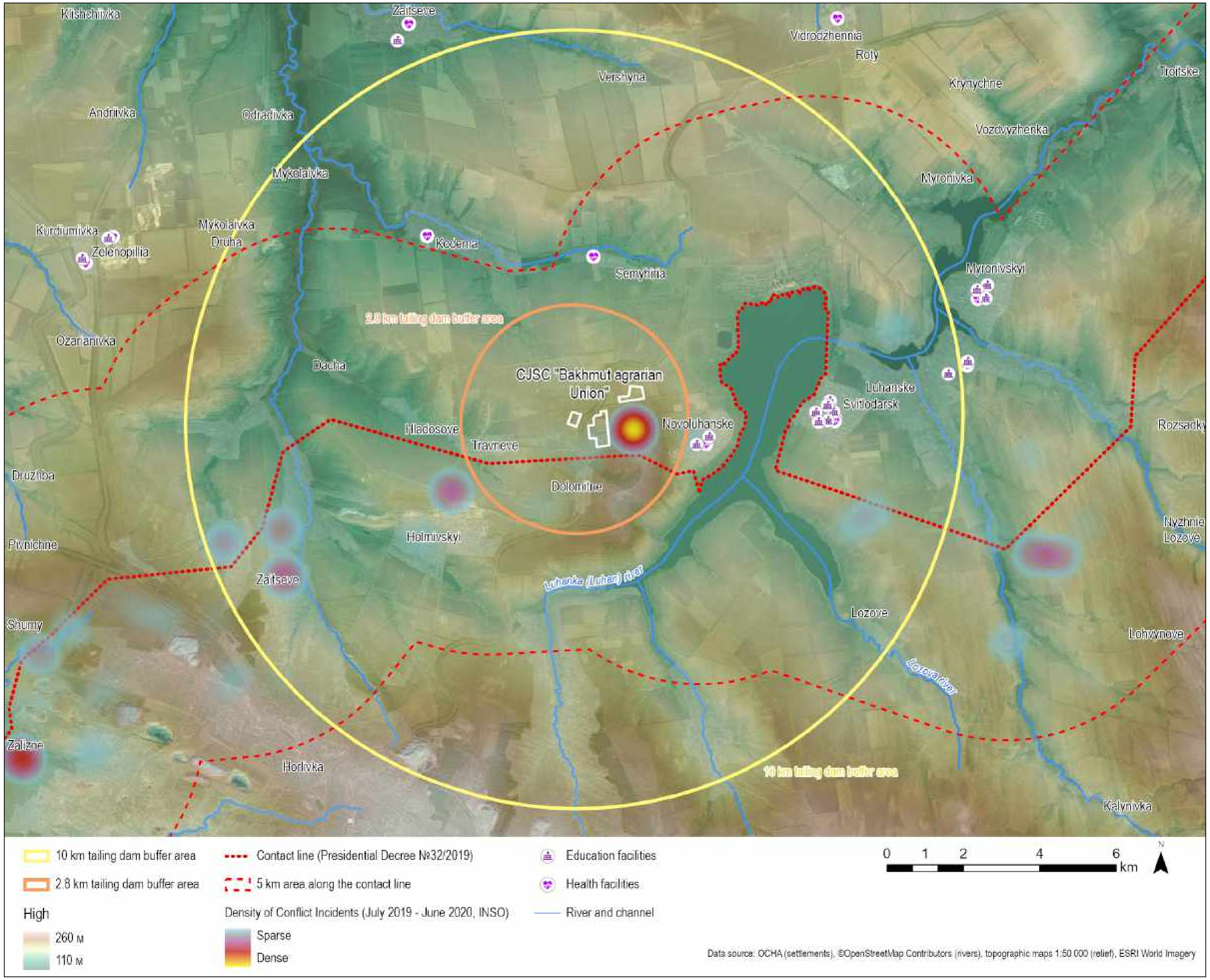
According to the technological process, sewage from the pig farm is purified at the treatment plant and then left to accumulate in the tailing dam. In the summer, the adjacent agricultural fields are irrigated from this tailing dam. Since the beginning of the conflict, these fields have not been cultivated as the area is covered by landmines, and the sewage was not utilized. Due to the lack of security it became difficult to access the pond and drain the sewage. As a result, runoff from the tailing dam began to enter the soil and riverbeds of nearby rivers. It is estimated that the tailing dam contained about 4 million tons of sewage (RadioSvoboda, 22.07.2016).

Pig farm sewage contains disinfecting agents, antibiotic and hormonal products, pesticides, which may have a long-term impact on the environment and are classified by the Globally Harmonised System of Classification and Labeling of Chemicals (GHS) as aquatic acute class 1. According to FEAT, the hazardous susbstances may transfer through soil and groundwater between distances of 2.8 to 10km, and for more than 10km through river (maps 4.2-4.3).

Map 4.2 Buffer area of 2.8km around Bakhmut Agrarian Union industrial pig farm



Map 4.3 Buffer area of 10km around Bakhmut Agrarian Union industrial pig farm



The settlements of Dolomitne, Novoluhanske and Travneve are located in the 2.8km buffer area of the pig farm and almost adjacent to the Luhanka River. Up to 20 settlements, along with Bakhmutka River are located within the 10km buffer area which is under potential risk of groundwater pollution. Bakhmut River flows into Siverskyi Donets river, the main source of drinking water to the region.

Samples collected in 2018 at the confluence of Bakhmutka River and Siverskyi Donetsk River revealed the MPC overage for a number of substances, in particular SO4 concentration was 10 times higher than MPC (graph 7.1, p.23). River water samples near Kodema indicated that ammonia concentration was up to 19 times higher than MPC. Livestock illnesses were also reported by residents of nearby villages (RadioSvoboda, 22.07.2016).

As a result of shelling striking the sewage storage tailing dam on July 11, 2016, waste leaked and entered the Kodemka River and the Bakhmutka River. Residents' cattle in the village of Kodema died due to consumption of contaminated water from the River Kodemka at a distance of 2km from the point of waste leakage from the tailing dam. Water samples revealed the 12MPC increase for ammonia as a result of this incident (State water agency of Ukraine).

Groundwater accounts for 55% of water intake in the Bakhmut River Sub-basin, and 59% of water intake is used for drinking and sanitizing requirements (graphs 6.1-6.2). Most of the households in rural settlements rely on groundwater from wells. For example, in Kodema village, there is no centralized water supply. This increases the risk of contamination spread and influences agricultural production, livestock and human health.

Key takeaways

1. Develop a management plan for pig farm sewage utilization.

2. Conduct detailed hydrological analysis including taking groundwater samples of household wells.

2. Establish river water quaility monitoring posts to inform population about pollution increase.

Hazard Description

Because Donbas is a heavily industrialized region with a large coal and metallurgical industry, it suffers from the highest levels of air pollution in Ukraine. According to WHO, air pollution poses a major threat to health and climate, causing around seven million premature deaths annually, primarily due to stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections.

Air pollution is generated both by anthropogenic and natural processes. Sources include gases (e.g. ammonia, carbon monoxide, SO2, nitrous oxide, methane, CFCs); particulates, and biological molecules.

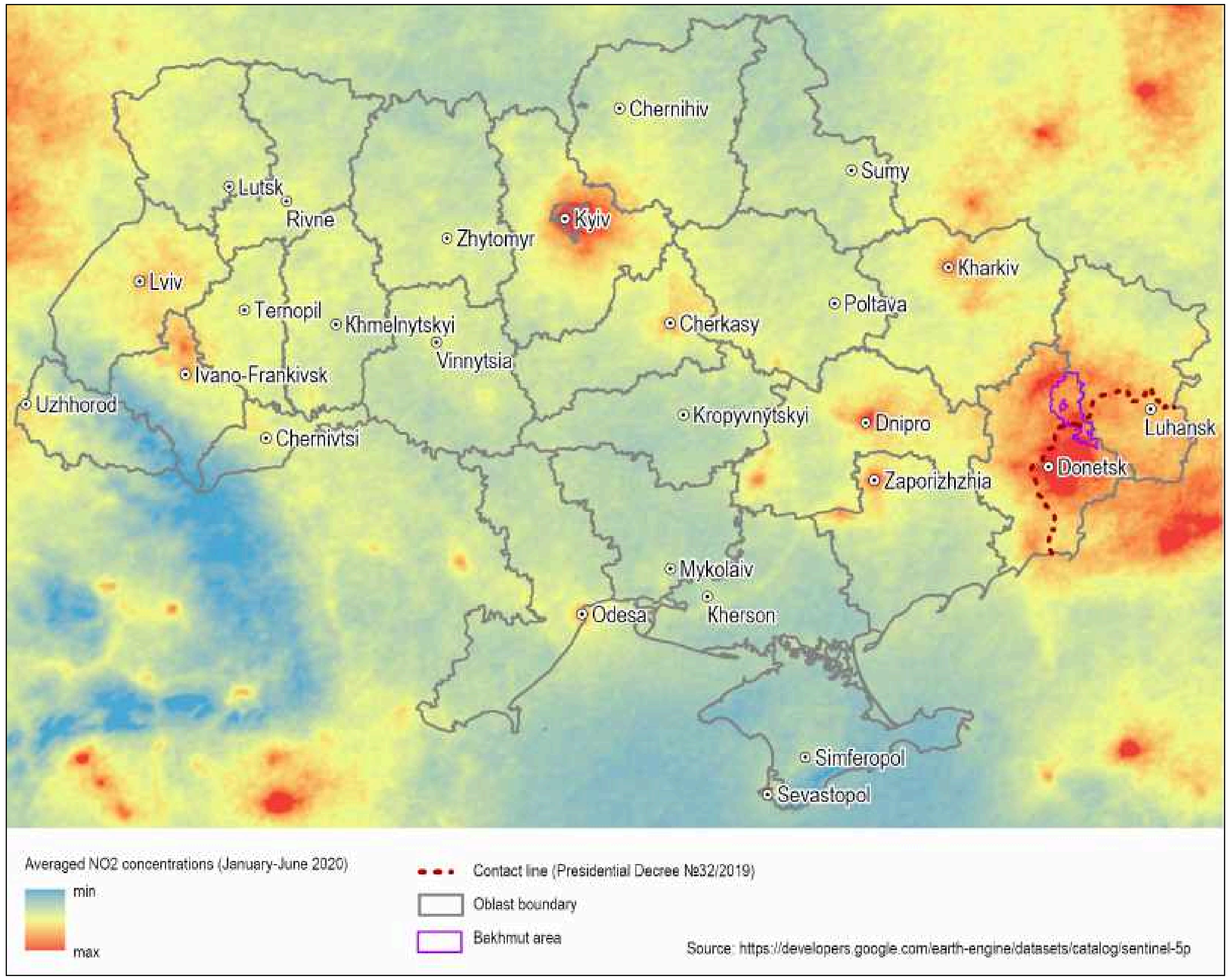
To fulfil Ukraine's obligations in the EU Association Agreement, the Ukraine Cabinet of Ministers amended the Procedure for State Monitoring of Air Quality in August 2019. To implement the requirements of Directive 2008/50/EC & Directive 2004/107/EC, the list of pollutants that must be monitored was defined and MPC of airborne substances was set according to EC Directives.

Donetska Oblast has an automated environmental monitoring system established in 2017 and includes 44 air quality monitoring posts. It is operated by the Department of Ecology and Natural Resources of the Donetsk Regional State Administration and Donetska SESU Department. Four posts are located in Bakhmut area; specifically Bakhmut, Myronivsky, Svitlodar and Soledar settlements. On maps 5.2-5.5, points represent locations of monitoring posts and the dot size indicates the number of days during the first 3 months of 2020 when pollution exceeded MPC.

Although data from the NGCA is unavailable, satellite imagery (map 5.2) shows the area around Donetsk has high NO2 emissions, along with the area north of Kramators. Thus, satellite data can effectively contribute to understanding regional pollution dynamics.

Since July 2018, the European Space Agency Sentinel-5P satellite mission has been collecting global atmospheric data on Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Carbon monoxide (CO) and aerosol concentrations in the atmospheric column.

Map 5.1 NO2 emissions in Ukraine



Graph 5.1 Seasonal dynamics of NO2 concentration in the air in 2019

Raion Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly mean
Bakhmutskyi	1.64	1.03	1.01	1.08	0.92	0.95	1.07	0.93	0.94	1.01	0.79	0.85	1.02
Dobropilskyi	1.70	0.95	0.87	1.02	0.90	0.98	0.91	0.93	0.89	0.85	0.73	0.64	0.95
Lymanskyi	2.07	0.94	0.96	0.93	0.93	0.89	0.94	0.90	0.92	0.88	0.76	0.79	0.99
Manhushskyi	0.81	0.70	0.70	0.87	0.81	0.93	0.88	0.89	0.83	0.79	0.67	0.64	0.79
Oleksandrivskyi	1.87	0.92	0.84	1.03	0.90	0.95	0.87	0.93	0.95	0.80	0.71	0.61	0.95
Pokrovskyi	1.47	0.99	0.87	1.09	0.93	1.00	0.92	0.94	0.93	0.89	0.76	0.63	0.95
Slovianskyi	2.12	1.00	0.94	1.13	0.97	0.98	0.94	0.98	1.11	0.95	0.82	0.73	1.06
Velykonovosilkivskyi	1.01	0.85	0.79	0.99	0.86	1.04	0.88	0.88	0.93	0.83	0.70	0.62	0.86
Volnovaskyi	1.00	0.93	0.79	0.98	0.85	0.99	0.92	0.90	0.88	0.88	0.72	0.66	0.88
Yasynuvatskyi	**1.66**	**1.16**	**0.98**	**1.16**	**0.95**	**1.02**	**0.96**	**0.95**	**0.94**	**0.97**	**0.82**	**0.73**	**1.02**

In combination with on-the-ground air monitoring posts, it is an effective tool to detect primary pollution sources and assess settlement-level pollution risk. As atmospheric emissions can spread over large areas, 3-month averaged satellite data from January-March 2020 were used as anthropogenic hazard exposure indicator 2.3 to identify protracted emission sources in the region.

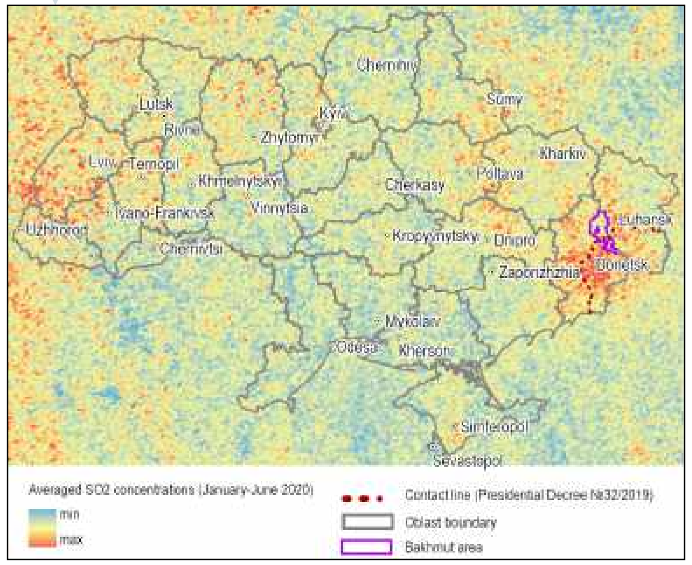
SO2 MPC was exceeded on >50% of days at all observation points in the Donetsk region. At Pokrovsk and Volodymyrivka, SO2 MPC exceedance was recorded on 100% of days, and on >90% of days in 7 settlements (Svitlodarsk, Mariupol, Soledar, Bakhmut, Mykolaivka, Novotroitske and Kurakhove).

Slovyanska TPS in Mykolayivka recorded NO2 MPC exceedance on all days, whilst exceedance on > 88% of days was recorded in Kostiantynivka, Mykolaivka, Novotroitske and Mariupol. Overall, 27/42 observation points recorded >50% of days with NO2 MPC exceedance.

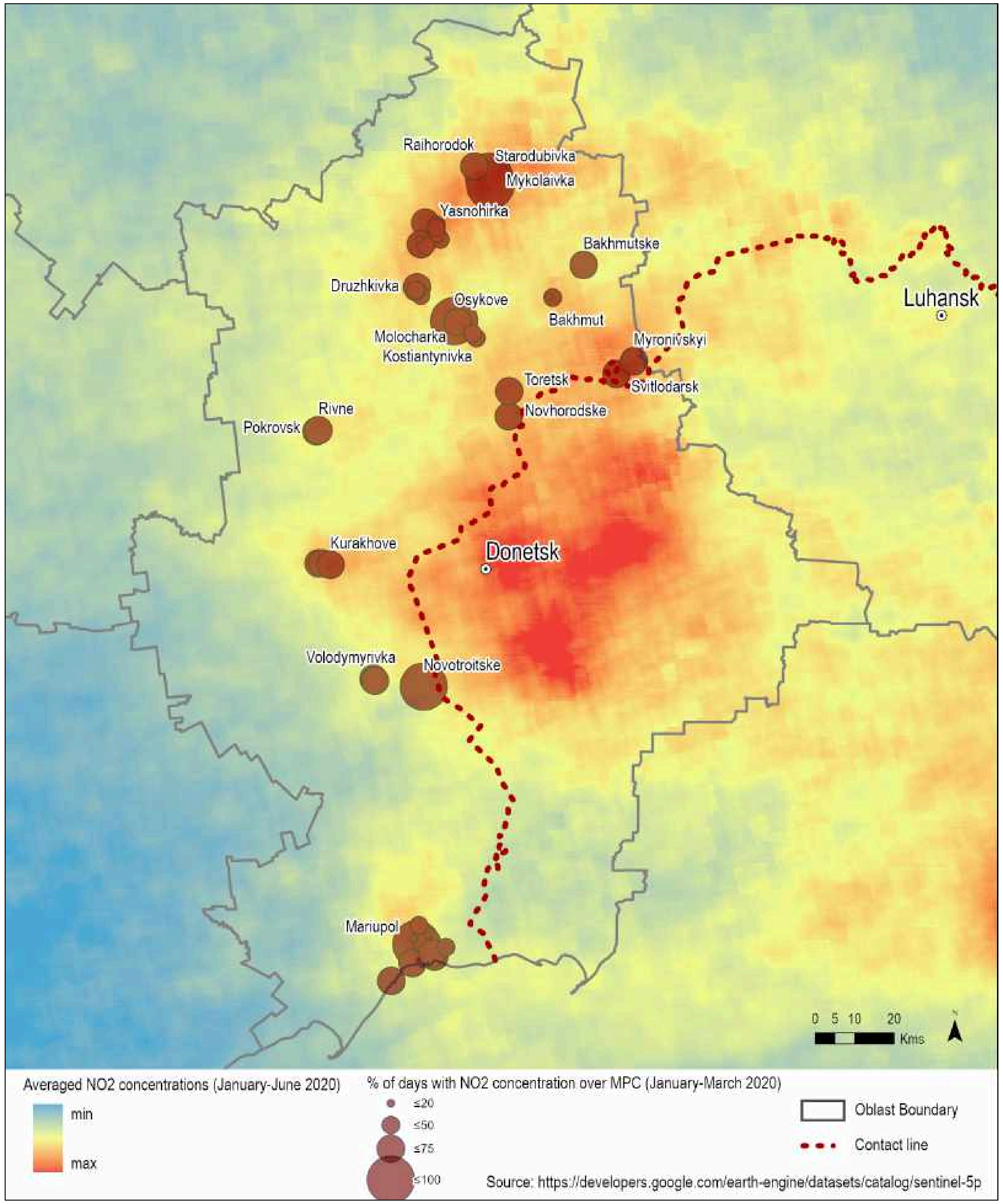
Regarding pm10 fraction, 32/42 observation points recorded MPC exceedance on > 50% of days. At air monitoring posts in Mariupol and Kostiantynivka, MPC exceedance was recorded on all days, whilst Kurakhove recorded exceedance on >85% of days.

In 14/42 observation points, >50% of days recorded pm25 MPC exceedance. The highest percentage of days with exceedance (77%) was observed at Kostiantynivka and 71% in Yasnohirka.

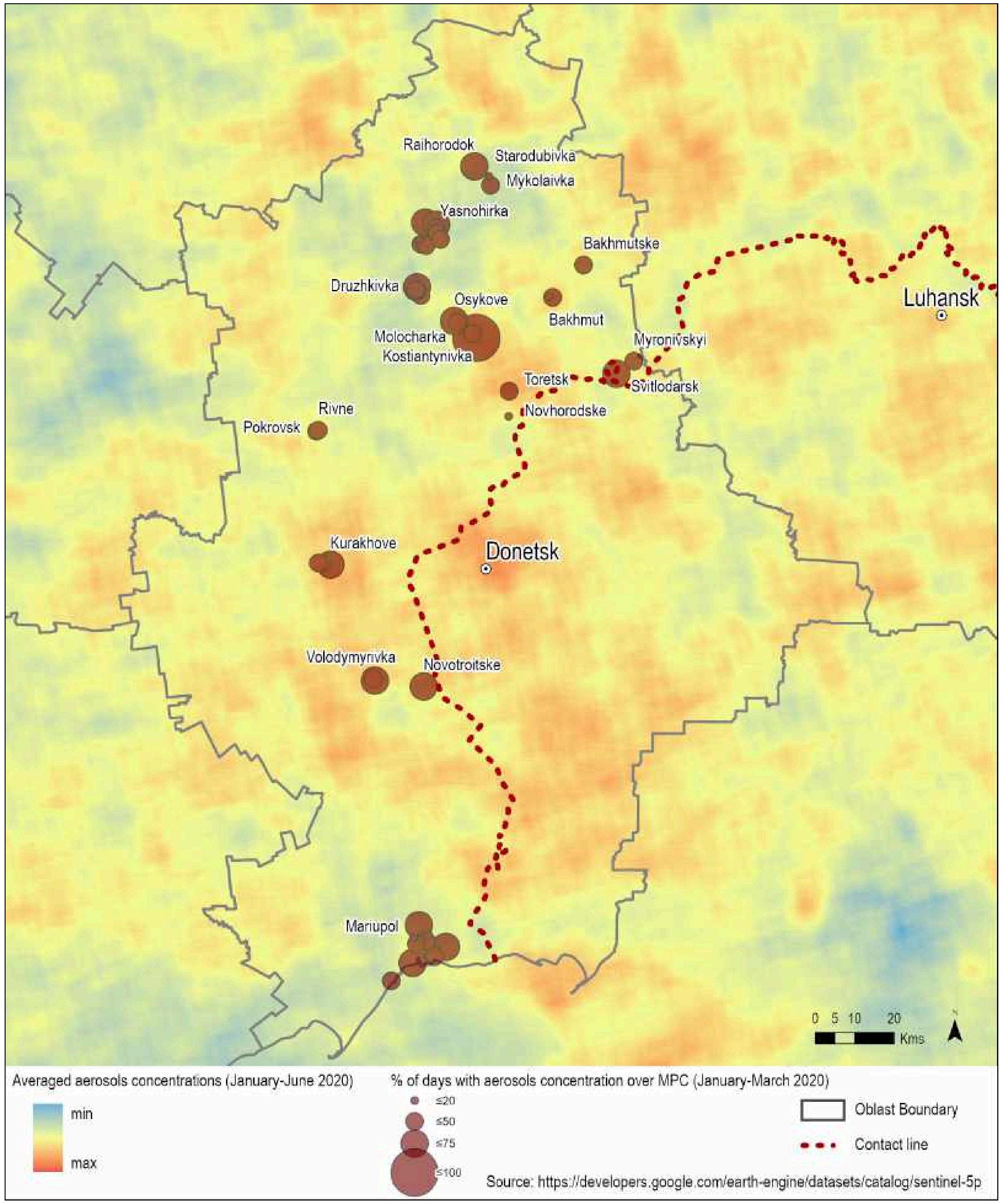
Map 5.2 SO2 emissions in Ukraine



Map 5.3 NO2 emissions in Eastern Ukraine



Map 5.4 Aerosols concentration in Eastern Ukraine



Bakhmut Raion air pollution

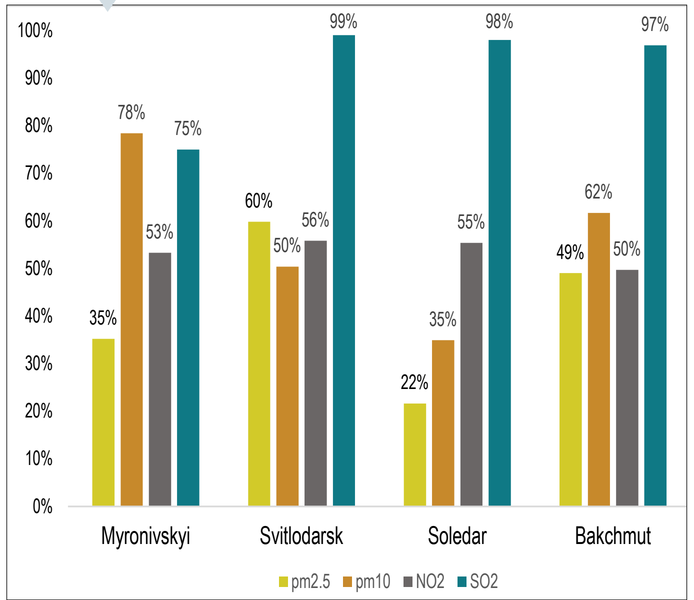
According to data from 4 air monitoring posts in Bakhmut area, SO_2 concentrations exceeded MPC on more than 75% of days, whilst NO_2 concentrations exceeded MPC on 50-56% of days during the observation period between January 1 and June 30, 2020.

Regarding days when particulate concentrations exceeded MPC (pm10 and pm2.5), Soledar had the lowest rate at 35% and 22%, respectively. The highest rate for pm10 concentrations was 78% of days at Mironovskiy, whilst the highest rate for pm2.5 concentrations was 60% of days at Svitlodarsk.

The chemical and coal industries are the primary SO_2 polluters in the area. Plants include ISTEK coke and chemical plant, Horlivka chemical plant and Yenakieve steel plant, which are located in the NGCA along the southern border of Bakhmut area. No official information is available about plant operations and emissions in the NGCA, although Sentinel-2 satellite images reveal recent blast furnace operations at ISTEK coke and chemical plant and Yanakieve steel plant (fig. 5.1-5.2).

The figures are false-colour composites based on Sentinel-2 bands 4, 8 and 12; the red, IR and SWIR bands respectively. In the images, vegetation shows up as bright green, water as black, and industrial sites as

Graph 5.1 Percentage of days with MPC overage (January-June, 2020)



Map 5.5 SO_2 concentration in Bakhmut area

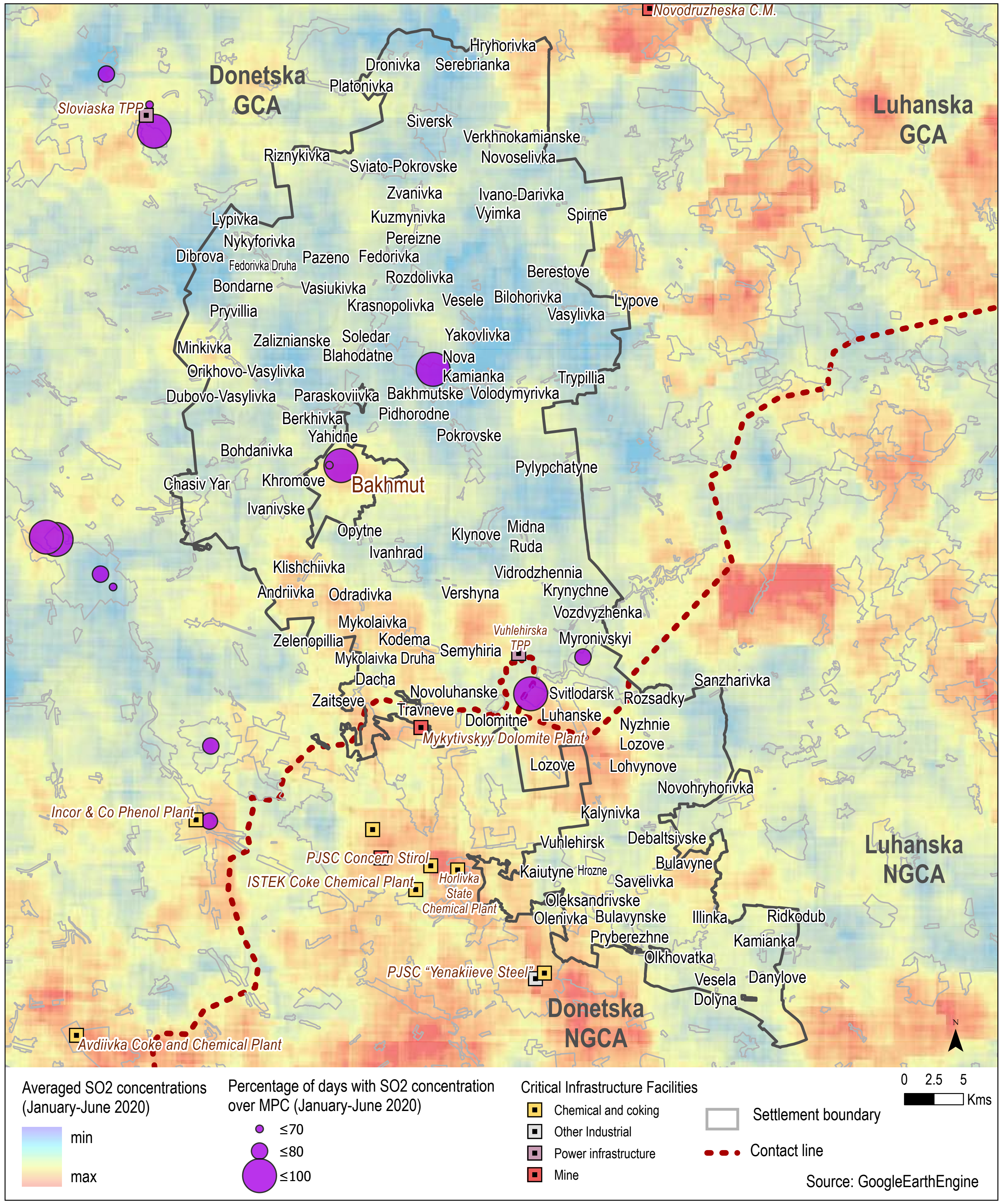


Figure 5.1. Blast furnace operations and dust cloud around ISTEK coke and chemical plant (Horlivka), on Sentinel-2 image, August 31, 2020

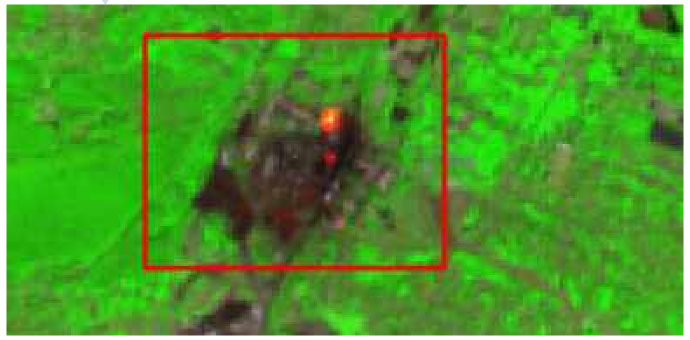
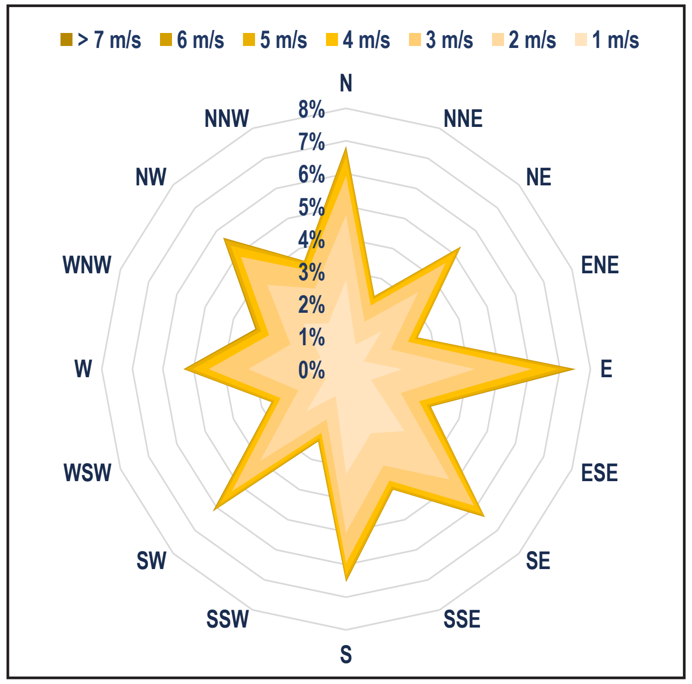


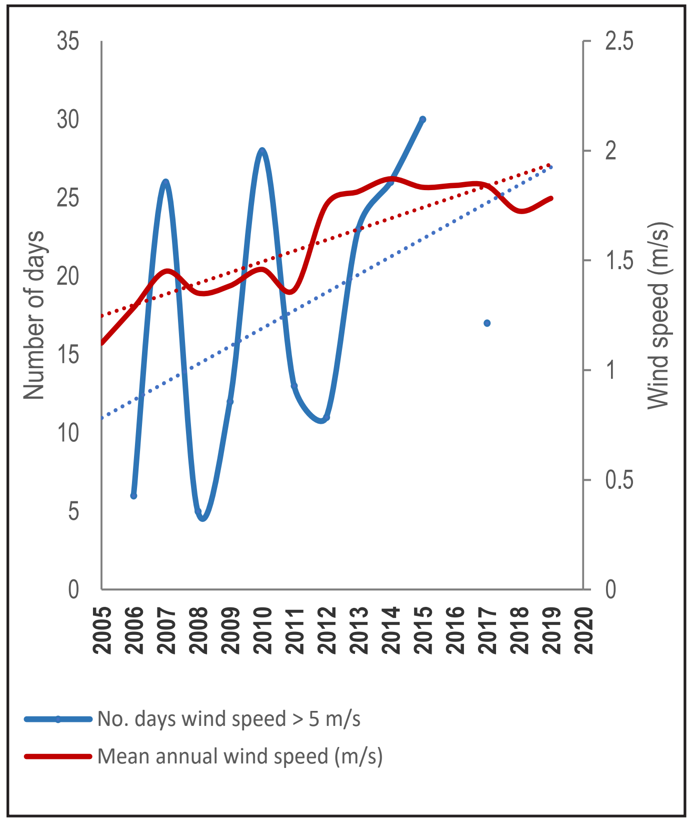
Figure 5.2. Blast furnace operations and dust clouds of Yenakieve steel plant, on Sentinel-2 image, August 31, 2020

Figure 5.3. Dust cloud from Vuglehirska TPS on Sentinel-2 image, March 4, 2020

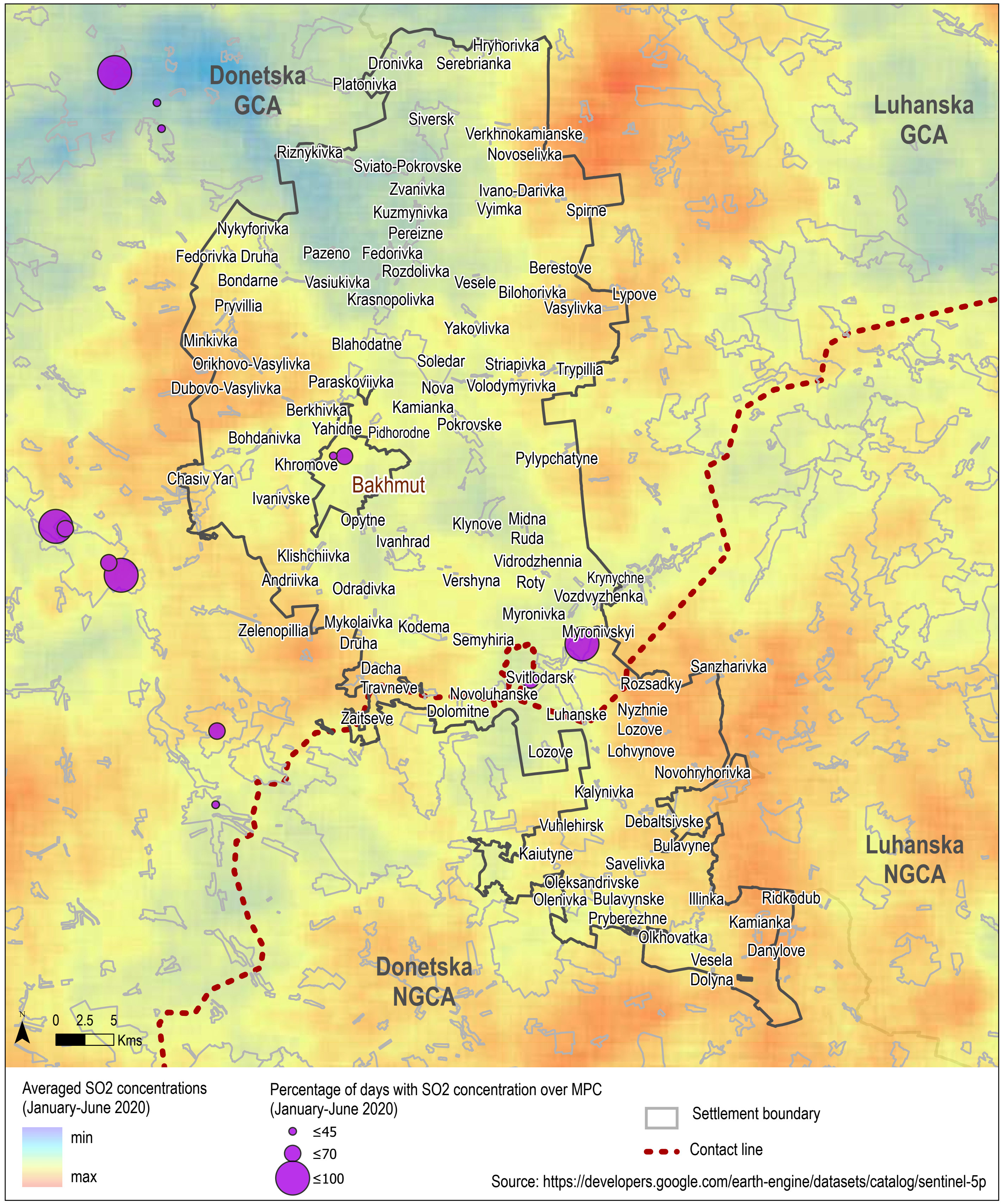
Graph 5.2 Average wind direction



Graph 5.3 Yearly-averaged wind speed dynamic



Map 5.6 Aerosol emissions in Bakhmut area



brown. The red spots indicate the working blast furnaces.

Vuglegiska TPS, which utilises fossil fuels, is another source of air pollution in the area. In the Sentinel-2 satellite image (fig. 5.3), a dust cloud has spread from the TPS over a 3km area, visible as a dark grey haze. Agricultural land in this image appears as a rose-red and light green colour.

Satellite data also confirms higher NO_2 concentrations in the region compared to other parts of Ukraine. Chronic exposure to NO_2 and SO_2 can cause respiratory or lung diseases. Aerosol particles with an effective diameter <10µm can enter the bronchi and those with an effective diameter <2.5µm can enter as far as the gas exchange region in the lungs, a serious human health hazard.

Storm winds can trigger the dispersion of aerosol pollutants across a wider area. Above wind speeds of 5 m/s, dust and ash from bare and degraded land can become disturbed through wind erosion (deflation), potentially polluting nearby soils and water bodies.

Graph 5.2 and 5.3 summarise average wind direction and speed between 2005 and 2019 using records from Bakhmut weather station. Depsite insufficient data in 2016 and 2018-2019, the number of days with wind speeds above 5 m/s shows an increasing trend, peaking in 2015. Average wind speeds also increase over this period, although the trend remains steady after 2013-2014. Increasing frequency of storm winds is one of the consequences of climate change, especially in the steppe zone, in which Bakhmut area is located.

Understanding wind direction is important in determining trends in air pollution dynamics. Graph 5.2 shows the trends in wind directions over the last 14 years, but there is no clear prevailing wind direction. The greatest wind speeds are from the east and north, potentially leading to greater dispersion of pollutants from factories in the heavily-industrailised NGCA.

Key takeaways

1. Installation/repair of filtration systems & air emission monitoring systems near hazardous objects is required.

2. Include air pollution monitoring data into Bakhmut alert system and increase the awareness and usage of air monitoring systems, including mobile Apps like IQAir or SaveEcoBot to plan daily activities, especially outdoor activities in schools.

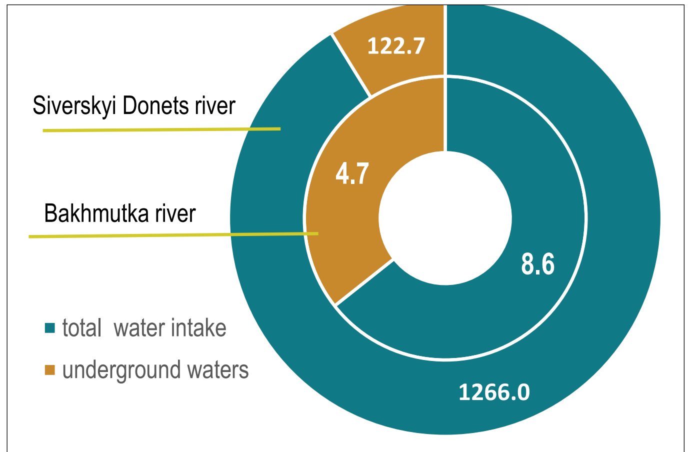
Hazard Description

Hydrological and water basin mapping is an important tool to increase understanding of water contamination risks, which may have cascading health consequences for domestic, commercial and industrial activities.

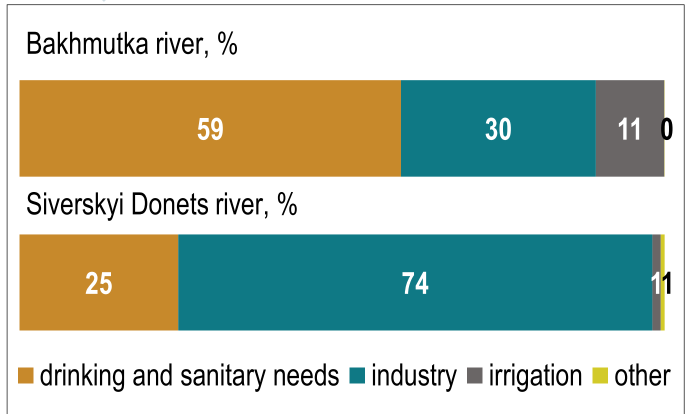
Most of Bakhmut Raion is located in Bakhmut river sub-basin, part of Siverskyi Donets river basin. The southern part of Bakhmut Raion is divided between Luhan and Krynka river sub-basins.

Siverskyi Donets River provides most of the water resources for Donetska Oblast. The river collects inflow from smaller tributaries and groundwater and surface runoff, eventually flowing into the Dnieper-Donbas Channel. Due to the proximity of many hazardous facilities, water sources are at risk of contamination from sewage, as well as coal mine and spoil tip wastewater.

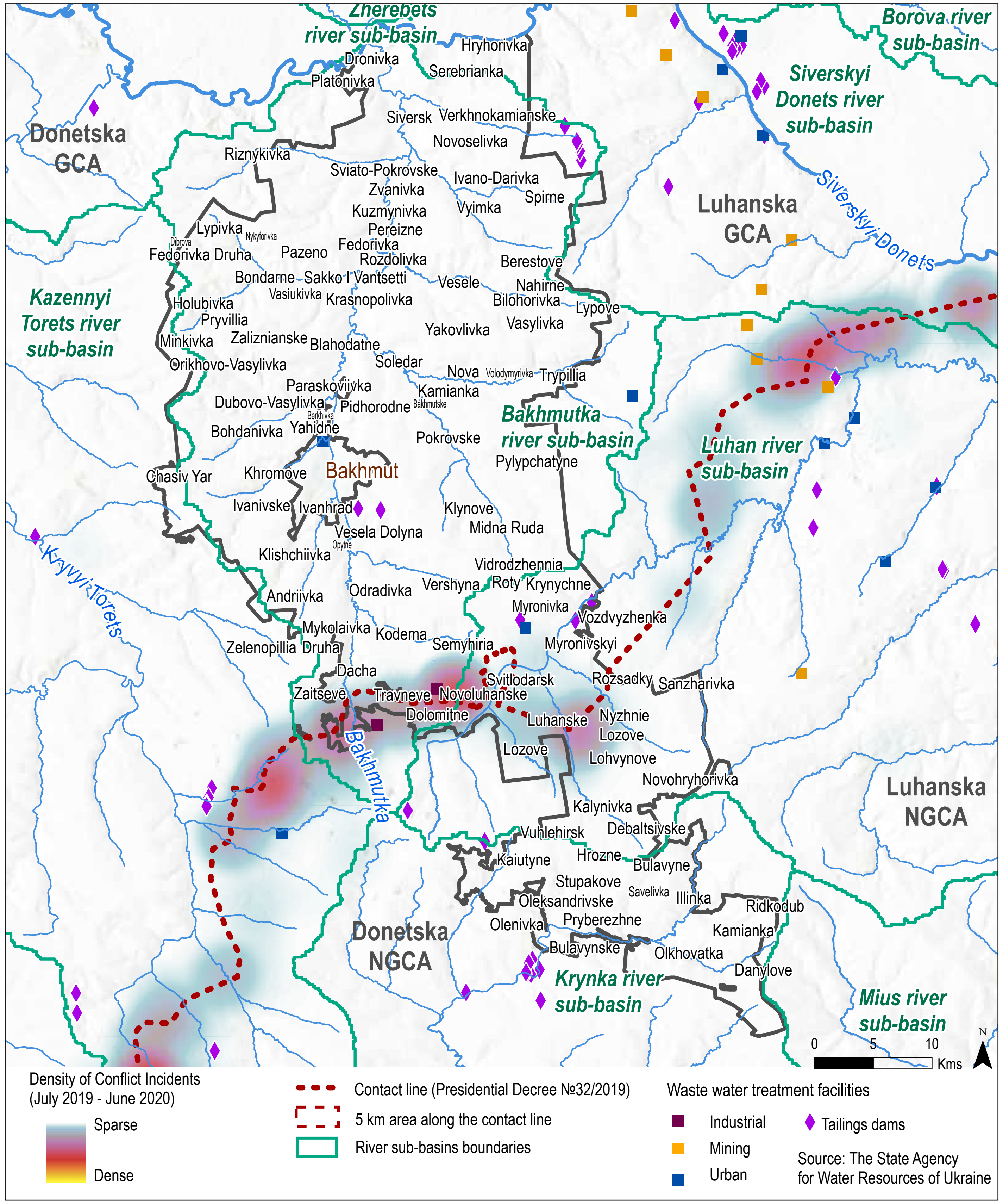
Graph 6.1. Basin water intake in 2018 (mln.m3)[6]



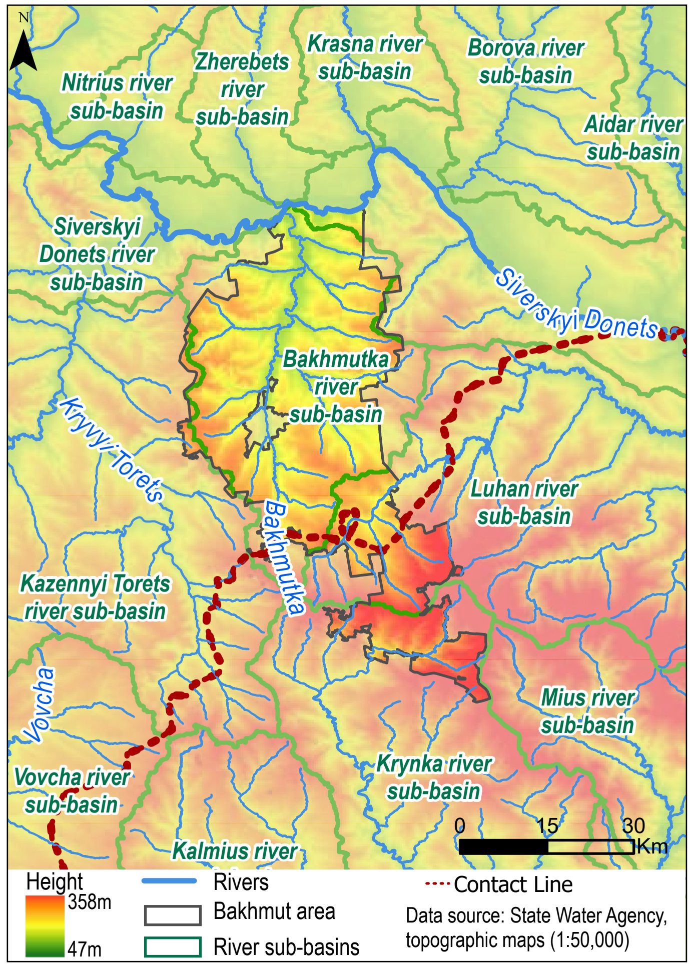
Graph 6.2. Basin water usage type in 2018[6]



Map 6.1 River Basins and Hazardous Facilities



Map 6.2 Regional Overview of Main Rivers



The industrial pig farms of Bakhmut Agrarian Union are located in the upper part of Bakhmutka River. This is an area frequently affected by conflict incidents, exposing downstream populations to potential biological hazards in case of sewage tailing dam damage.

Fifty-five percent of the total water intake in Bakhmutka River sub-basin is from groundwater, compared to just 9% in Siverskyi Donets basin. This indicates the importance of groundwater research, especially close to the pig farm. Up to 59% of the water intake of Bakhmutka river sub-basin is used for drinking and sanitation, compared with just 25% in Siverskyi Donets basin. Eleven percent of water intake is used for irrigation in Bakhmutka river sub-basin, which is also higher compared to 1% in the area of Siverskyi Donetsk River basin.

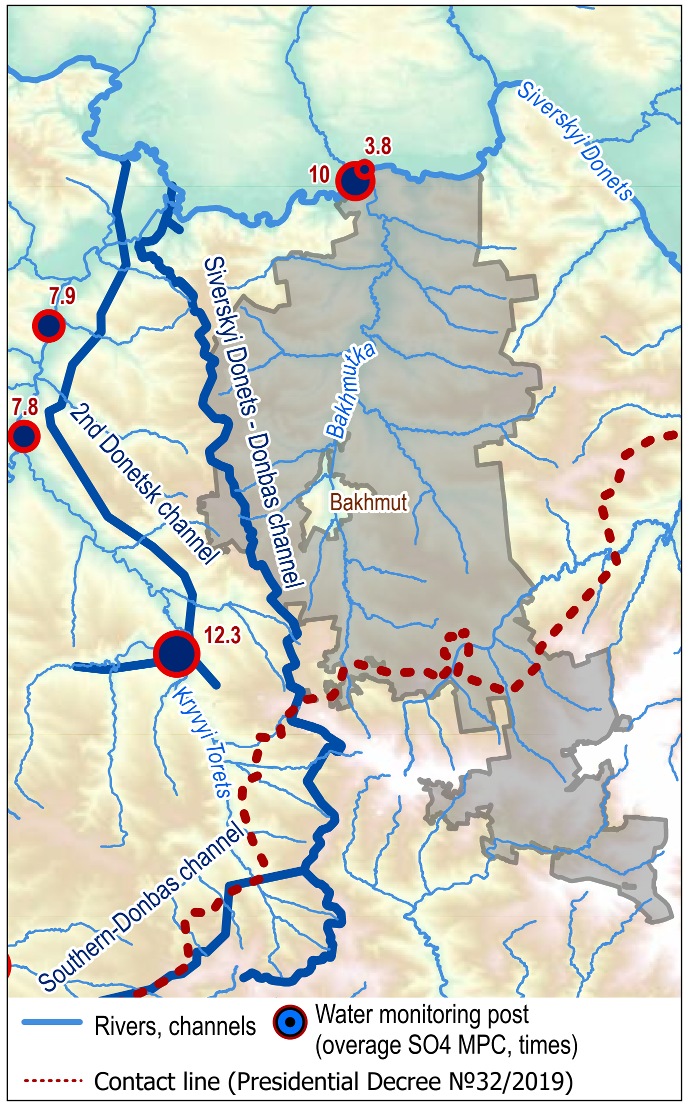
6) Water intake and quallity data from the State Water Agency of Ukraine (https://www.davr.gov.ua/)

Water Network

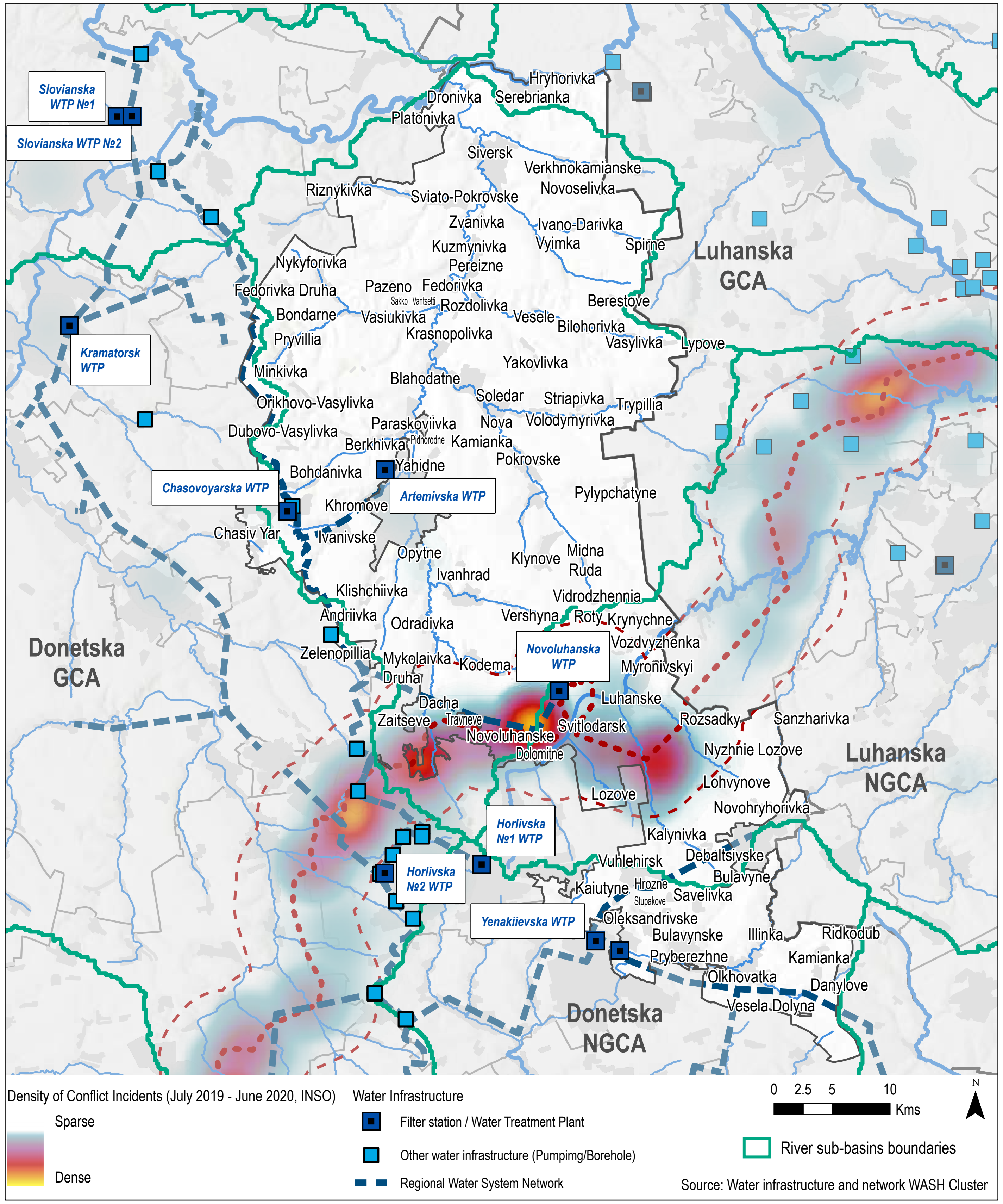
Functional water infrastructure is critical to ensure basic water and sanitation needs. Water is supplied to the region through the Siverskyi Donets - Donbas channel to Donetsk and then through Southern-Donbas channel to Mariupol. The infrastructure consists of 17 water tanks and 18 water filtering stations (water treatment plants). 3 water filtering stations and 3 pumping stations are located in Bakhmut area.

Surface water quality along the Siverskyi Donets River in Donetska Oblast are mainly classified according to the State water agency of Ukraine[6] as

Map 7.1 Regional Overview of Water Network



Map 7.2 Water Infrastructure



satisfactory, slightly polluted (class III category 4). The average yearly MPC was exceeded in Siverskyi Donets in 2018 for ammonium, nitrogen (up to 2.4 MPC), iron (2.2 MPC), manganese (2.7-11.3 MPC), copper (2.5-4.6 MPC), petroleum products (2.5 MPC), nitrites (5.5 MPC), chromium (3.8-7.7 MPC) and zinc (2.6 MPC).

Close to Bakhmut area, water samples were collected on December 12, 2019 at the Bakhmutka River (near Bakhmut and Dronivka settlements) and Siverskyi Donets River (Dronivka settlement). Two water quallity indicators were tested for - suspended solids and dissolved oxygen, revealing the overage up to 1.4 MPC for suspended solids in Bakhmutka River. In Siverskyi Donets River, no MPC overage for suspended solids and dissolved oxygen were detected.

A more comprehensive analysis of water samples at the same locations was conducted on November 6, 2018. Significant overage of MPC for sulfates was recorded at all 3 posts (up to 10 MPC at Bakhmutka River, and up to 3.8 MPC at Siverskyi Donets River downstream (map 7.1). Slight MPC overage for chloride ions (1.4 MPC) was recorded in Bakhmutka River, as well as for nitrite ions (up to 1.75 MPC) in all 3 locations.

The water supply system crossing the CL is frequently damaged due to shelling and obsolete equipment, which leads to the interruption of the water supply for several days and weeks. 54 conflict incidents were recorded in 2019 near Mayorska pumping station, and 38 in the first 6 months of 2020, according to INSO data. The pumping station is used to pump water to maintain the required levels in the Severskyi Donets-Donbas channel. Ten conflict incidents occured near Popasna pumping station in 2019 and 3 incidents in 2020.

Three water treatment plants in the study area are located close to the CL and areas of higher frequency of conflict events. The water treatment process utilizes chlorine, which according to FEAT, would be lethal to humans at a distance from 0.4 to 1.3km, in case of an explosion.

HAZARD - WASTEWATER MANAGEMENT

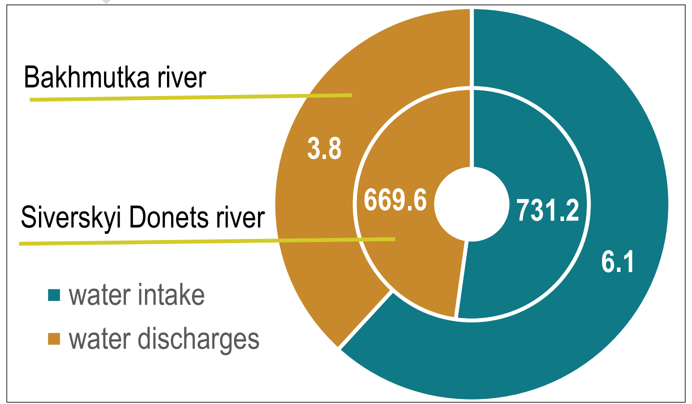
Hazard Description

Wastewater is broadly defined as water that has been contaminated by human use. United Nations Water identifies the following sources of wastewater: domestic water used for sanitation purposes (toilets, kitchens and showers); water from commercial establishments (restaurants) or institutions (hospitals or schools); water from industrial and agricultural activities; storm-water; and other urban run-off water.

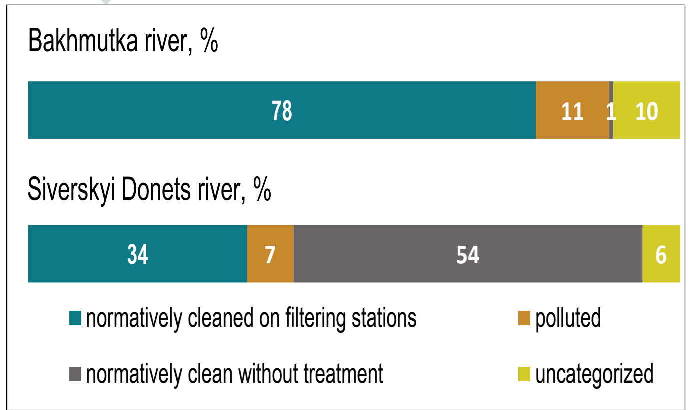
Wastewater management can be potentially hazardous as flammable liquids, acids and solvents are often used in such facilities (OCHA/UNEP, 2016) and inadequate treatment can lead to contamination of groundwater sources.

Water of Donbas Company carries out water extraction, distribution, transportation, supply and treatment in Donetska Oblast within both the GCA and

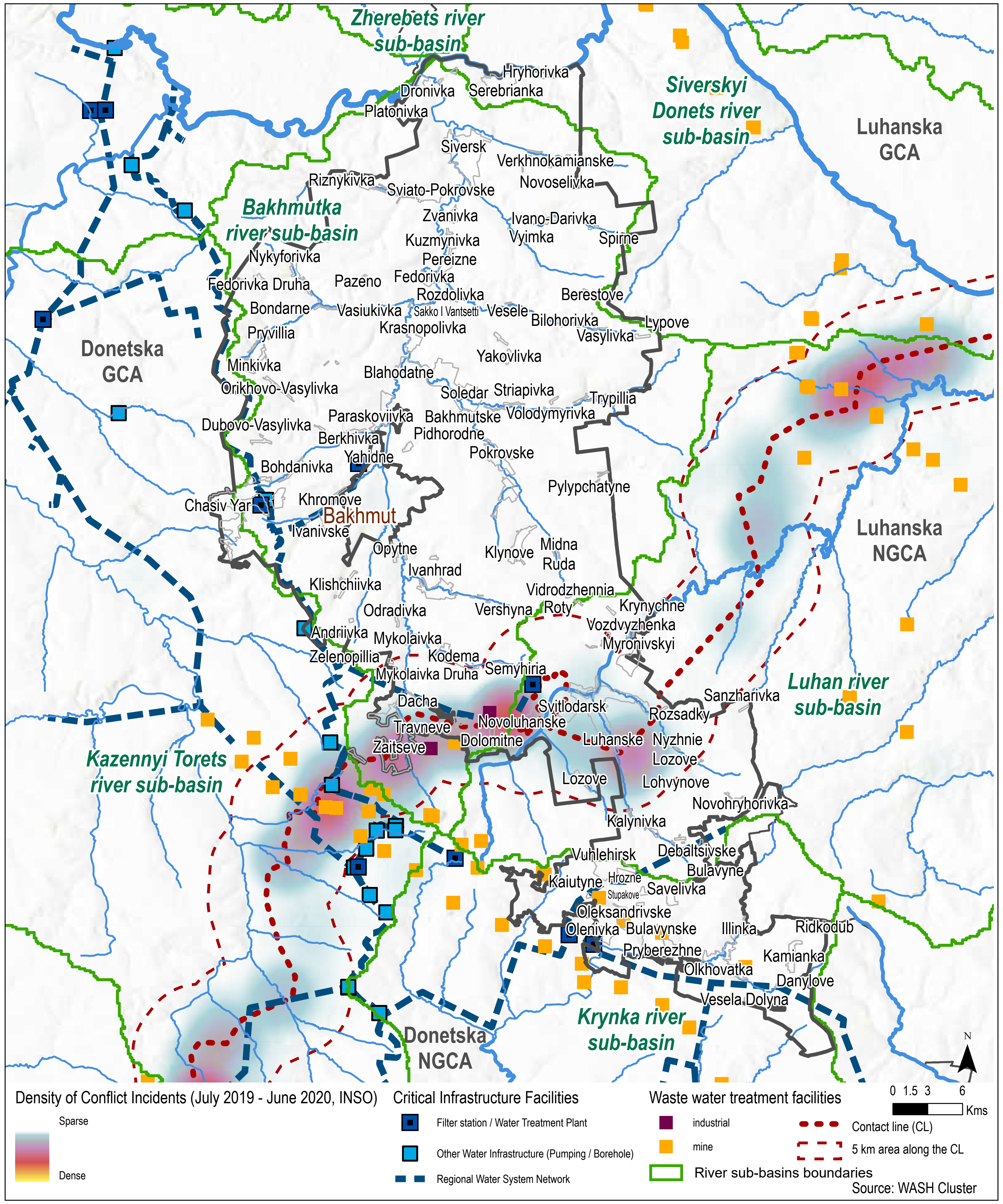
Graph 8.1. Basin water discharges in 2018 (mln.m3)[6]



Graph 8.2. Water treatment in 2018[6]



Map 8.1 Wastewater Treatment Facilities Location



NGCA.

According to information from the State Water Agency, 78% of Bakhmut River sub-basin water discharge is normatively cleaned at filtering stations, compared to 34% in Siverskyi Donets River basin. However, significant overage of MPC for sulfates was recorded in the entire Bakhmutka River (up to 10 MPC, map 7.1), as well as MPC overage for other substances (nitrites, chlorides, dissolved oxygen, etc.).

Major wastewater treatment facilities are maintained by Bakhmut-Woda State Enterprise, providing sewage treatment for Bakhmut settlement and Bakhmut Agrarian Union, an industrial pig farm of up to 90,000 pigs, located near Novoluhanske settlement close to the CL. Due to the conflict, the wastewater treatment facilities of Bakhmut Agrarian Union are not sufficiently mantained, which has led to surface and groundwater pollution, as disscused in the case study section of this ABRA.

Key Takeaways:

1. Military activity in proximity to critical wastewater treatment facilities should be avoided to minimize the risk of wastewater contamination to water sources.
2. Monitoring of water quality at all stages of the water cycle is important to ensure that contaminated water does not jeopardize access to water or harm the environment.
3. Dialogue on sustainable solutions for the maintenance of these critical water systems should be reinforced.

Hazard Description

Donbas is a heavily industrialized area and industrial waste management from resource extraction is a continuous challenge. Two types of industrial waste storage are spoil tips and tailings dams. A spoil tip consists of accumulated waste material removed during the mining process, whilst a tailing dam is an earth-filled embankment dam used to store by-products of mining operations. Both are hazardous sites as they are storage locations of chemically dangerous substances.

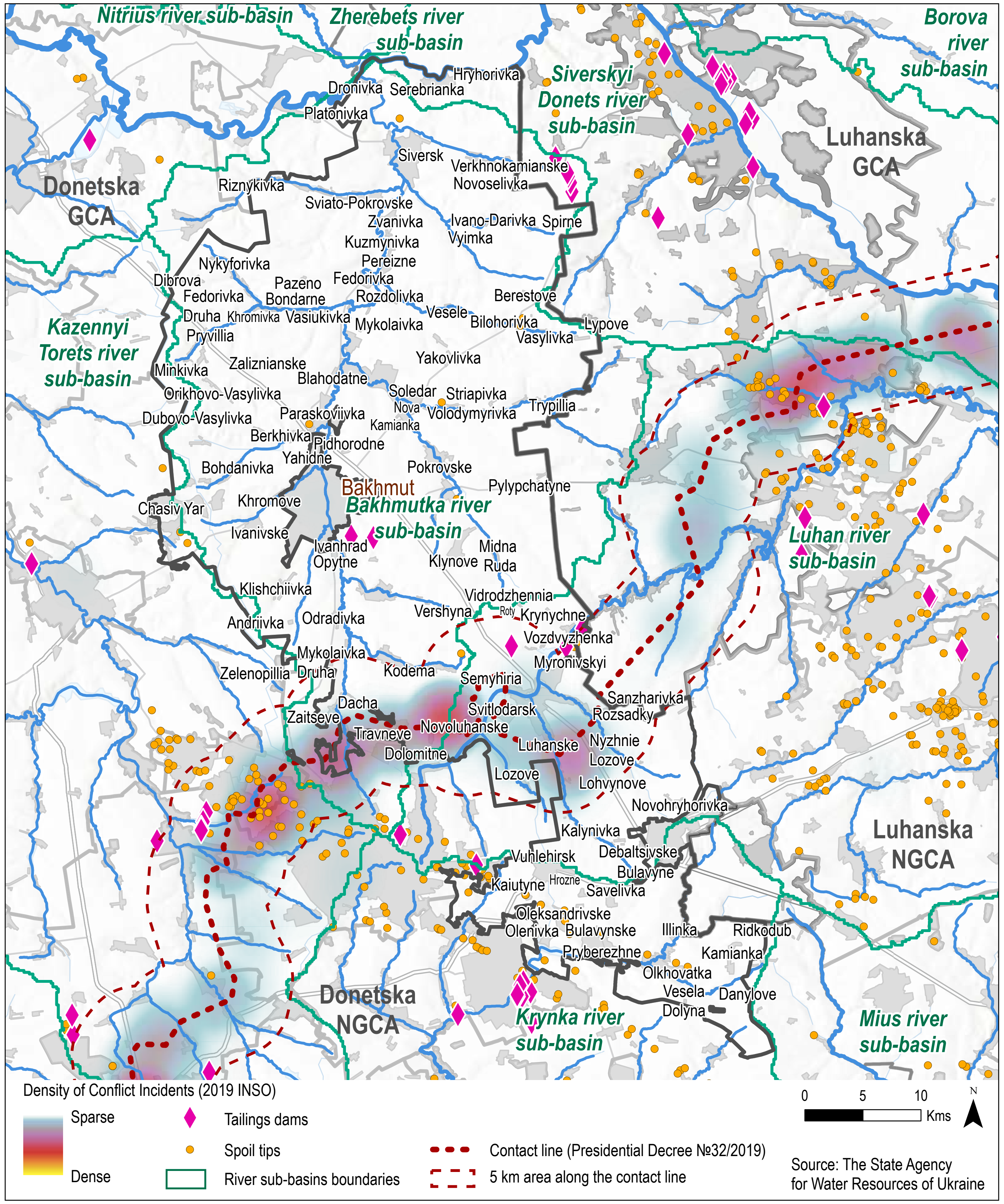
Bakhmut area is one of the largest salt mining regions in Ukraine, with 2 large operational salt deposits, one located near Bakhmut and the other in Soledar. In addition, there are clay deposits located near Chasiv Yar and a dolomite deposit for metallurgy near Siversk. Land subsidence and ground instability is a major risk in the area. Several areas of active subsidence have been identified close to residental buildings in Soledar and near the closed gypsum mine in Myhailivka settlement. The Bakhmut-Lysychansk highway, as well as the high-voltage transmission lines in the area, are also affected by karst processes, which may lead to subsidence development.

Bakhmut area is located between 2 major coal mining regions in Donbas, Toretsk-Horlivka coal mine network and Popasna Raion coal mine network. According to new prospective administration divisions, Toretsk City Council is planned to become part of Bakhmut Raion. Sixteen spoil tips are located within the settlement of Toretsk City Council and 14 additional spoil tips are located within 500m distance from the settlement boundaries (Toretsk ABRA, 2020).

To assess the exposure of the population to spoil tips, their locations were identified in relation to settlements. Since no official geo-database of spoil tips existed, the mapping was carried out by IMPACT using open source Open Street Map (OSM) data, cross-referenced with satellite imagery.

Tailings dams are a special hydro-technical construction designed to store by-products of industrial activity. The main hazards posed by tailing dams are dam failures, which represent low probability high impact events; and diffuse pollution, which has a higher probability but lower impact. Due to the proximity of tailing dams to the CL, there is concern over regular maintenance and potential damage (as disscused in the case study section of this ABRA).

Map 9.1 Spoil Tips and Tailings Dams Location



Map 9.1 displays tailings dams, conflict incidents recorded between July 2019 and June 2020, and rivers which may be exposed to contamination in the case of liquid waste discharge. Tailing dams of Incor&Co phenol plant and Bakhmut Agrarian Union, containing thousand of tons of hazardous substances, are located less than 2km from the CL, in an area of dense conflict incidents, and remains one of the major environmental threats in the region.

Key takeaways

1. The FEAT 2.0 guide and the Ministry of Health Protections' Decree should be utilized to better understand the human and environmental exposure for each site of concern.

2. Further investigation must be undertaken to ensure proper maintenance of tailings dams and spoil tips and mitigation of their hazard exposure.

HAZARD - EXPOSURE OF ELECTRICITY NETWORK TO CONFLICT

Electricity

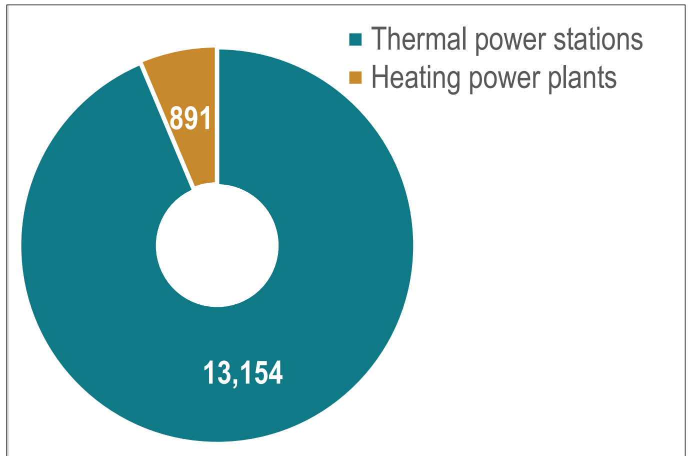
Electricity is critical for both domestic and industrial activities. Because of the linkages between electricity, heating and water supply systems, electricity shortages can have cascading consequences on households, inhibiting their ability to heat themselves and access water. This section provides a short overview of the electricity network and the main electricity-related risks in the raion. The dataset was created from digitized satellite imagery, secondary data sources and OSM contributors.

The electricity network of the area is part of the Unified Energy System of Ukraine, which unites 8 regional power systems (including Donbas power system), interconnected with domestic and interstate high-voltage power lines.

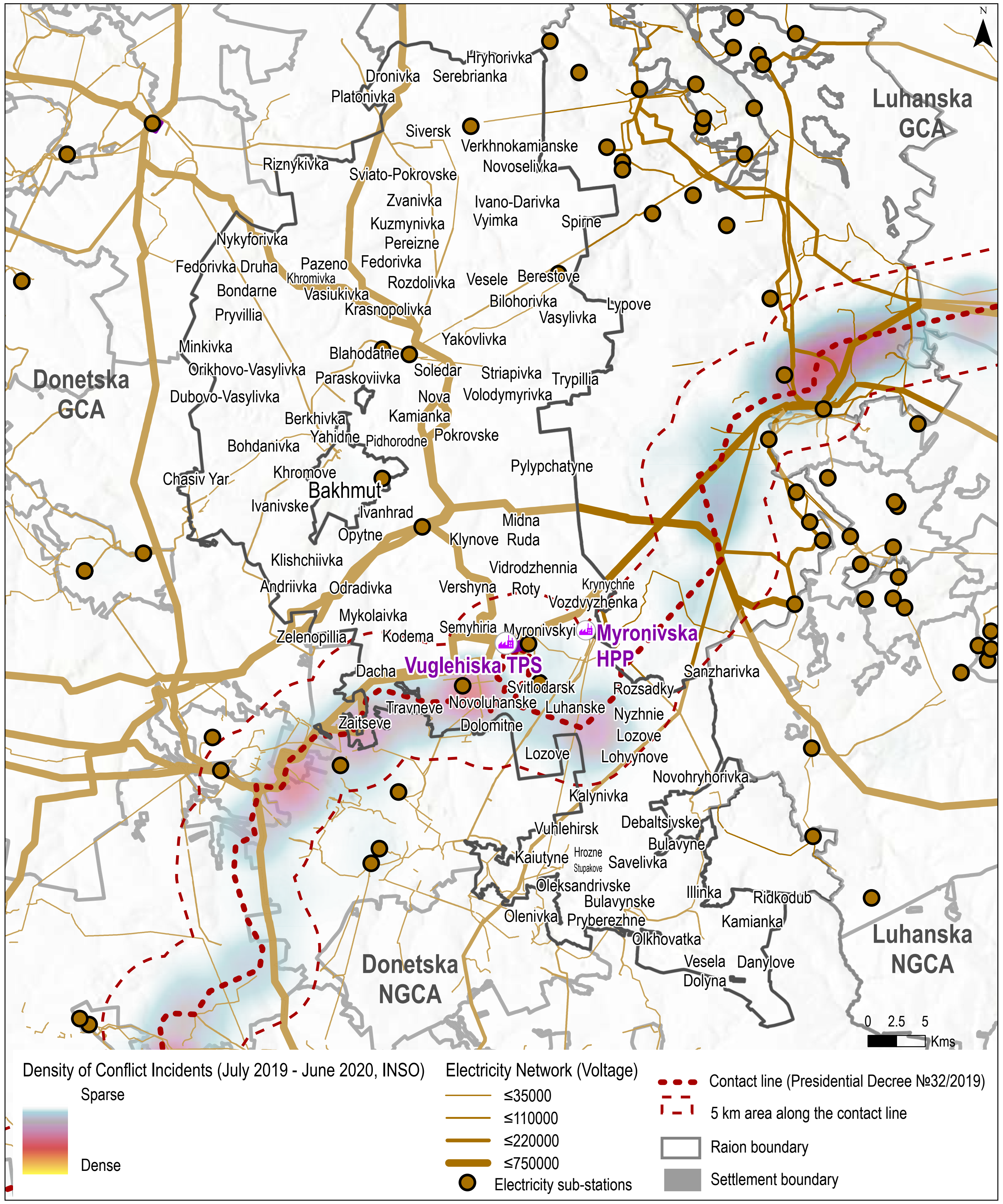
The main energy sources in the Donbas region are thermal power stations (TPS), which utilise fossil fuel, and heating power plants (HPP), based on water vapor (graph 10.1).

Power stations in the raion include Vuglehirska TPS, the major energy provider in the area, and Myronivska HPP. Both are located on the CL (map 10.1). Since the beginning of the conflict in 2014, 11 shelling events have been recorded near Vuglegirska TPS, resulting in infrastructure damage and malfunction. Early on March 29th, 2013, a fire caused by ignition of coal dust, destroyed four turbines at Vuglegirska TPS.

Graph 10.1 Production and source of energy in 2018[7]



Map 10.1 Electricity Network



Map 10.2. Vuglehirska TPS

There are 11 electricity substations located within the Bakhmut area. Nine conflict incidents were recorded between July 2019 and June 2020 near substations or within 1km of power-related objects.

Interruption of electricity supply has caused disruption to other dangerous facilities, coal mines, water filtration stations, water pump stations and more. This increases the risk of emissions of pollutants and hazardous substances into the environment.

Key takeaways

1. Due to the conflict and the possibility of network damage, diversification of power sources or improved connection for communities to the Ukrainian network would minimize the risk of large scale power outages.
2. Considering that an electrical critical infrastructure failure will induce several severe cascading effects, a multi-stakeholder risk assessment must be conducted by local authorities for specific response planning.
3. Finding methods to support and develop projects on solar panel installation by private households.

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7) Data provided by the Main Department of Statistics in Donetska Oblast, http://donetskstat.gov.ua/statinform1/energy.php)

8) Data collected by The Donbas Environment Information System (DEIS), https://deis.menr.gov.ua

Gas & Oil Pipelines

Similar to the electricity network, gas and oil pipelines are located in close proximity to the CL, with some 25km of pipeline passing close to the CL and 8 conflict incidents having occurred in several locations within a 500m radius of the pipelines (INSO, 2020). This infrastructure represents a disaster risk as damage can lead to oil or gas spills which can pollute both water and the atmosphere. In addition, both fuels are a major source of heating for the region, so damage could have critical consequences in the winter months.

The Horlivka-Odesa branch of the Toliati-Odesa ammonia pipeline also crosses the CL within the Bakhmut area. This branch was built in 1979 to transit liquid ammonia, produced at Stirol Plant, one of the largest ferliziler manufacturers in Ukraine, to the plant at Odesa Port in Yuzhne.

Since the beginning of the conflict in May 2014, the ammonia production and transit has been suspended due to security reasons. Despite the fact that Stirol plant management reported that all hazardous substances were removed from the industrial site, there is a concern that ammonia remains in the pipelines. As such, the northern part of Toretsk City Council, including Toretsk and Zalizne, is exposed to risk of ammonia leakage.

According to FEAT, ammonia is classified as a toxic liquid and aquatic chronic and may be channelled through air, soil, groundwater and rivers. It poses a danger to the environment, fishing, agriculture and human health in an area 2km - > 10km from source.

Key takeaways

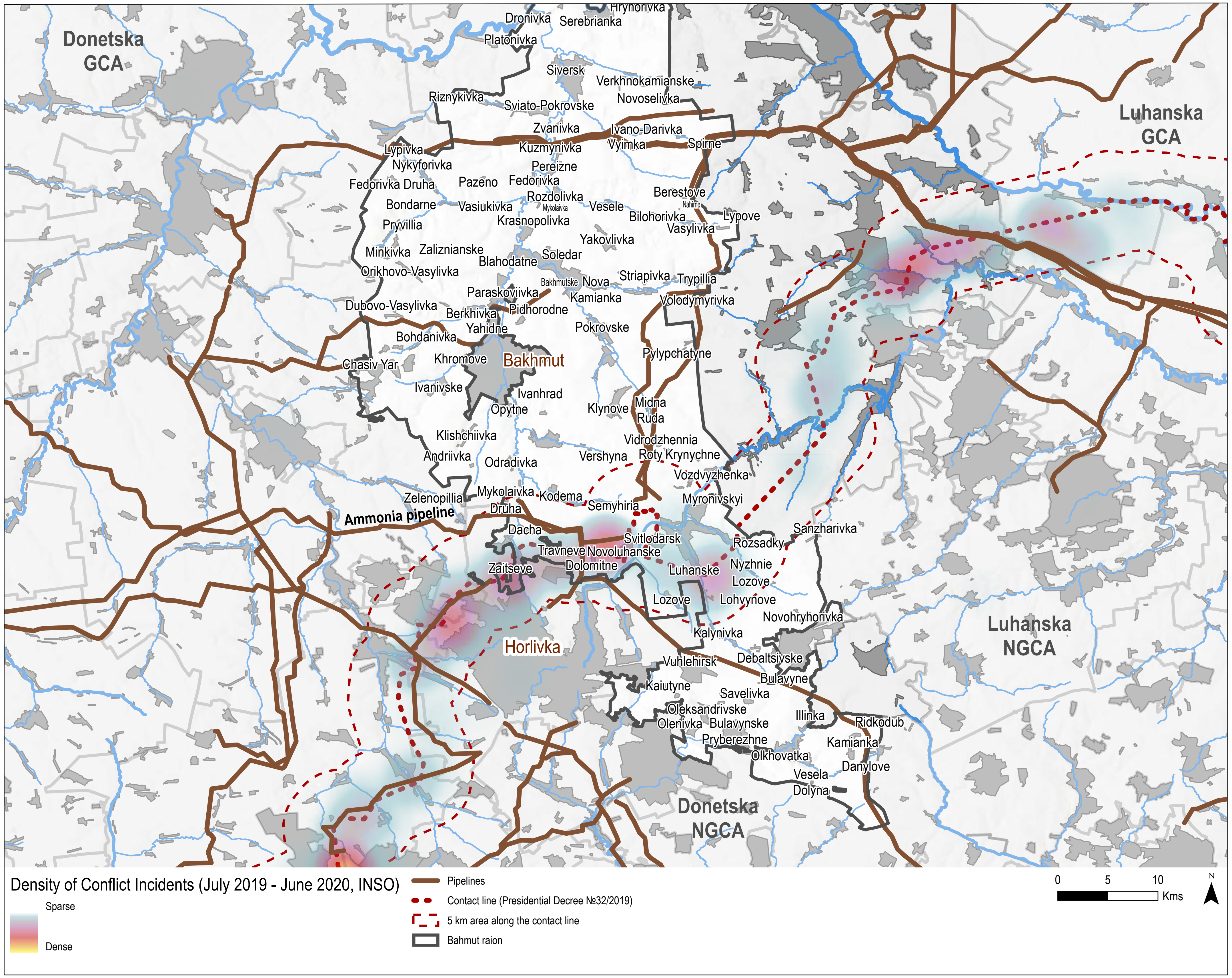
1. Monitoring of ammonia contamination in areas close to the pipeline.

2. Raise awareness of residents on risks related to exposure to ammonia and natural gas leaks.

3. Prioritize the demining operations along the pipeline routes.

9) PJSC Donetskoblgaz, http://oblgaz.donetsk.ua/hazoprovid-ocheretyne-avdiivka

Map 11.1 Gas and Oil Pipeline Network



Susceptibility & Coping Capacity

Based on indicators derived from the REACH 2018 CVA, rural settlements <5km from the CL were most susceptible. Susceptibility was derived from economic capacity and dependency. Although this same strata have high dependency, urban settlements <5km from the CL had the poorest economic capacity.

Economic capacity was based on unemployment rate and pensioners. As Graph 12.4 shows, pensioner status was the most common susceptibility. Although rural settlements <5km from the CL had many pensioners (47%), this was lower than urban settlements <5km from the CL (54%). Unemployment was 6.6% in rural settlements <5km from the CL, 8% >5km, and 5.1% in urban settlements <5km from the CL.

Dependency was based on proportion of population 65+; those with ≥ 1 disability; households with ≥ 3 children; those whose livelihood is agriculture; and where the HoH was a widow, single female or single parent. As Graph 12.1 shows, there is an uneven HoH gender distribution at 55% female and these are disproportionately affected by vulnerabilities (Graph 12.2). In total, over a third of households have one or more vulnerabilities (Graph 12.3).

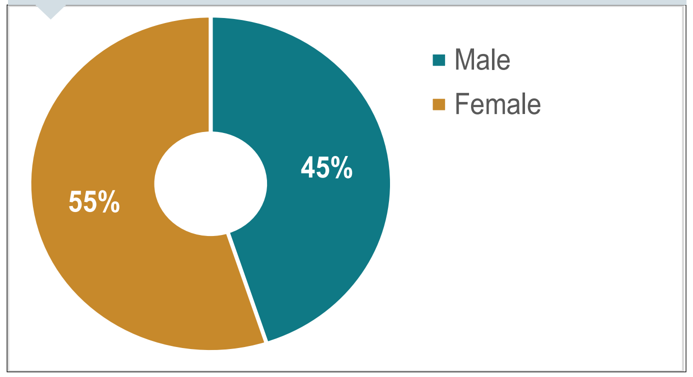
Urban settlements < 5km from the CL had the highest proportion of population aged 65+ (34.4%), whilst the lowest (22.7%) was found in urban settlements >5km from the CL. Although urban settlements <5km from the CL also had a high proportion of population with 1 or more disability (9.3%), the highest proportion was found in rural settlements > 5km from the CL (10.4%).

Settlements <5km from the CL have the highest proportion of vulnerable HoHs - 45.8% for urban and 36.9% for rural. Finally, rural settlements <5km from the CL had significantly higher proportion whose livelihood is agriculture than any other strata (24.1%).

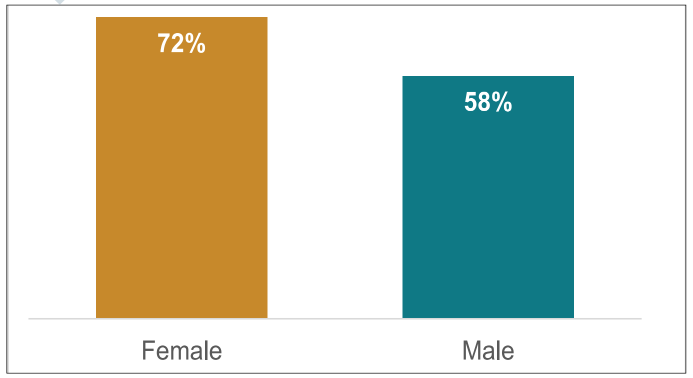
Coping capacity was calculated based on service access, bomb shelter awareness, IDPs and recent conflict events. Rural settlements <5km from the CL appear to suffer from the poorest coping capacity, whilst urban settlements have the highest overall.

Access to key facilities such as primary health care,

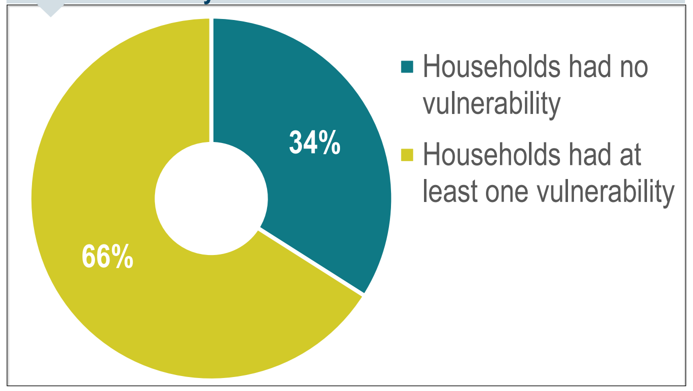
Graph 12.1 Gender Distribution of Heads of Households for Bakhmut area



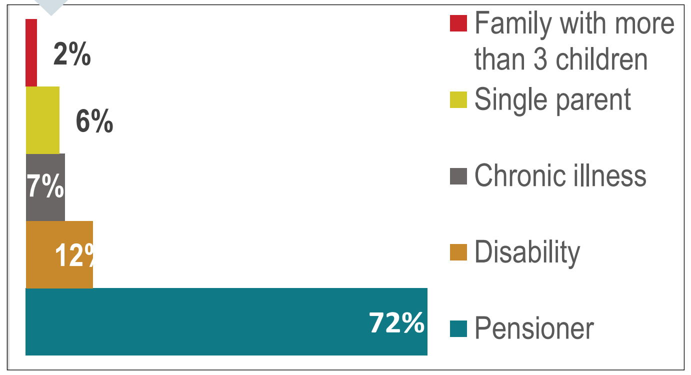
Graph 12.2 Gender Distribution of Heads of Households with Vulnerability for Bakhmut area



Graph 12.3 Distribution of Households that had at Least One vulnerability for Bakhmut area



Graph 12.4 The Most Common Types of Susceptibility of the Population for Bakhmut area



social services, education and SESU response units contribute to coping capacity. Urban settlements <5km from the CL had the best health care access, with 79% reporting <30 minutes to the nearest facility, compared to just 50% for rural settlements <5km from the CL.

Schools provide opportunities to communicate hazard preparedness/response and are often used for shelter and aid distribution following disasters. Educational facility access was relatively good across al strata, with 89% of rural settlement households > 5km from the CL reporting <30 minutes travel time at the lowest, and at the highest, 100% in urban areas <5km from the CL.

Social facilities provide essential services to vulnerable groups and can be used to communicate disaster preparedness and response information (REACH, 2018). The greatest proportion of population >20km distance from a facility were rural settlements <5km from the CL, whilst urban >5km from the CL had the best access, with 30% at <1km and 37% at 1-5km.

Hryhorivka, Kalynivka and Bohdanivka, all rural settlements >5km from the CL are located the furthest from a SESU unit. Urban settlements were generally in closer proximity, with Bakhmut, Siversk, Soledar and Sviltlodarsk each having their own SESU unit.

Zaitseve, Novoluhanske and Dolomitne (NGCA) each recorded 200+ conflict incidents in January 2019-June 2020. As for IDPs, urban settlements >5km from the CL reported the highest number. Just over 1/3 of the population is unaware of the nearest bomb shelter across all strata (38-41%), except for urban settlements under 5km from the CL, where just 12% are unaware.

Overall vulnerability is based on susceptibility and coping capacity. Rural settlements, in particular <5km from the CL, were more vulnerable than urban areas, with those > 5km from CL having the lowest vulnerability. Novoluhanske had the highest vulnerability overall.

The majority of vulnerability indicators are derived from the REACH CVA, which represents households stratified by Urban, Rural and within/beyond 5km of the CL, as shown in map 12.1 (confidence level 90%, margin of error 7%). Therefore, settlements across the research area have similar vulnerabilities based on settlement stratification. However, SESU unit distance and 2019 INSO conflict incidents provide insights into individual settlement-level findings. For example, within urban <5km from CL strata, Myronivskyi recorded 1 conflict event, compared with 124 in Luhanske, one of the highest records.

Zaitseve, an urban community located very close to the CL, recorded the highest number of conflict events (265). It was not however the most vulnerable community, due to lower susceptibility and dependency than rural settlements also <5km from the CL. Novoluhanske was the most vulnerable overall, whilst other rural settlements <5km from the CL were also amongst the most vulnerable.

Table 12. 1 Traveling Time to Education Facilities

Time	>5km Rural	>5km Urban	5km Rural	5km Urban
< 30 min	89%	94%	97%	100%
30 min - 1 hour	11%	6%	3%	0

Table 12.2 Traveling Time to Primary Health Care Facilities

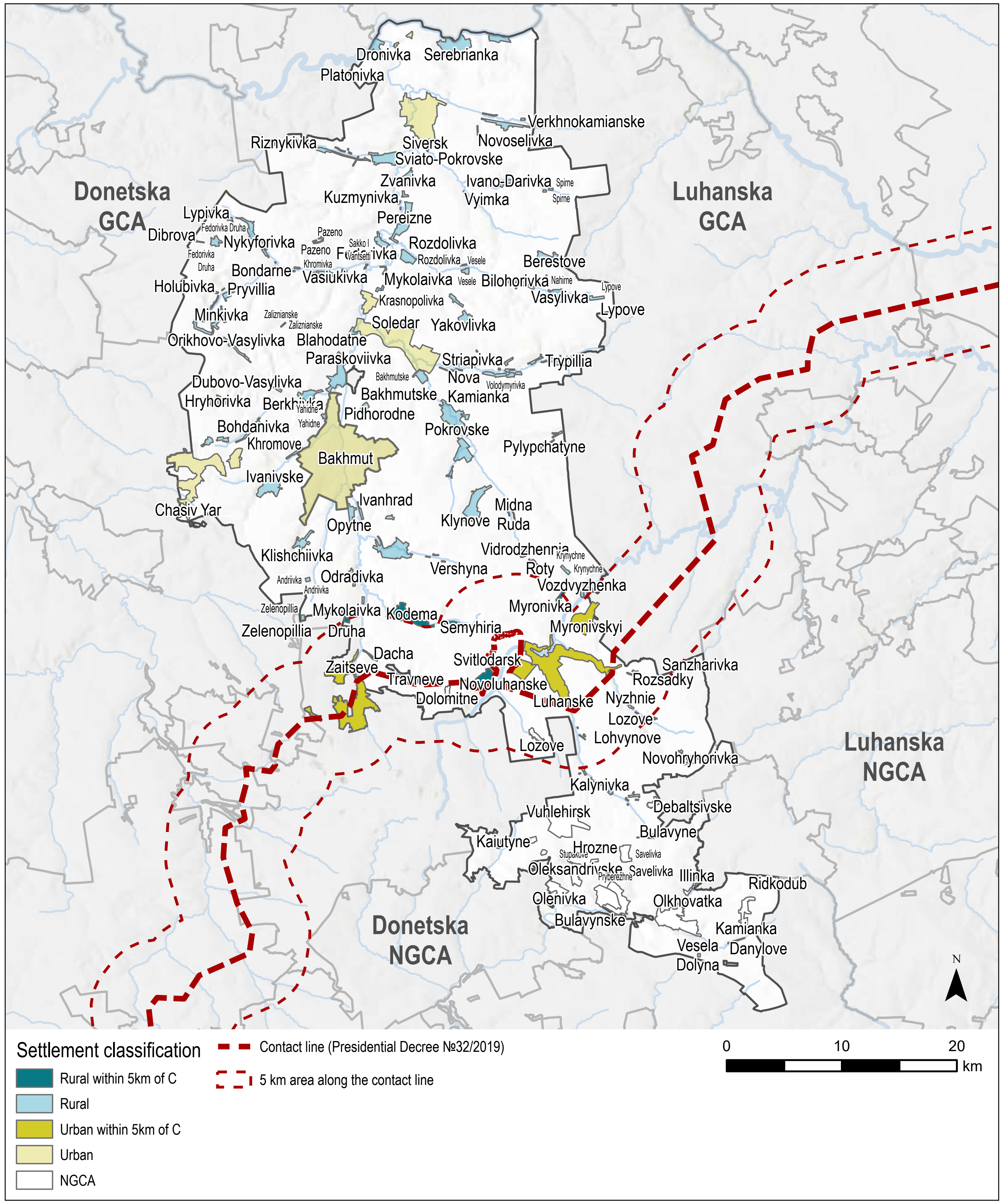
Time	>5km Rural	>5km Urban	5km Rural	5km Urban
<30 min	66%	71%	50%	79%
30 min -1 hour	30%	26%	38%	11%
1-1.5 hours	2%	2%	10%	6%
1.5 - 3 hours	1%	1%	1%	3%
> 3 hours	0	0	2%	1%

Table 12.3 Traveling Distance to Social Facilities

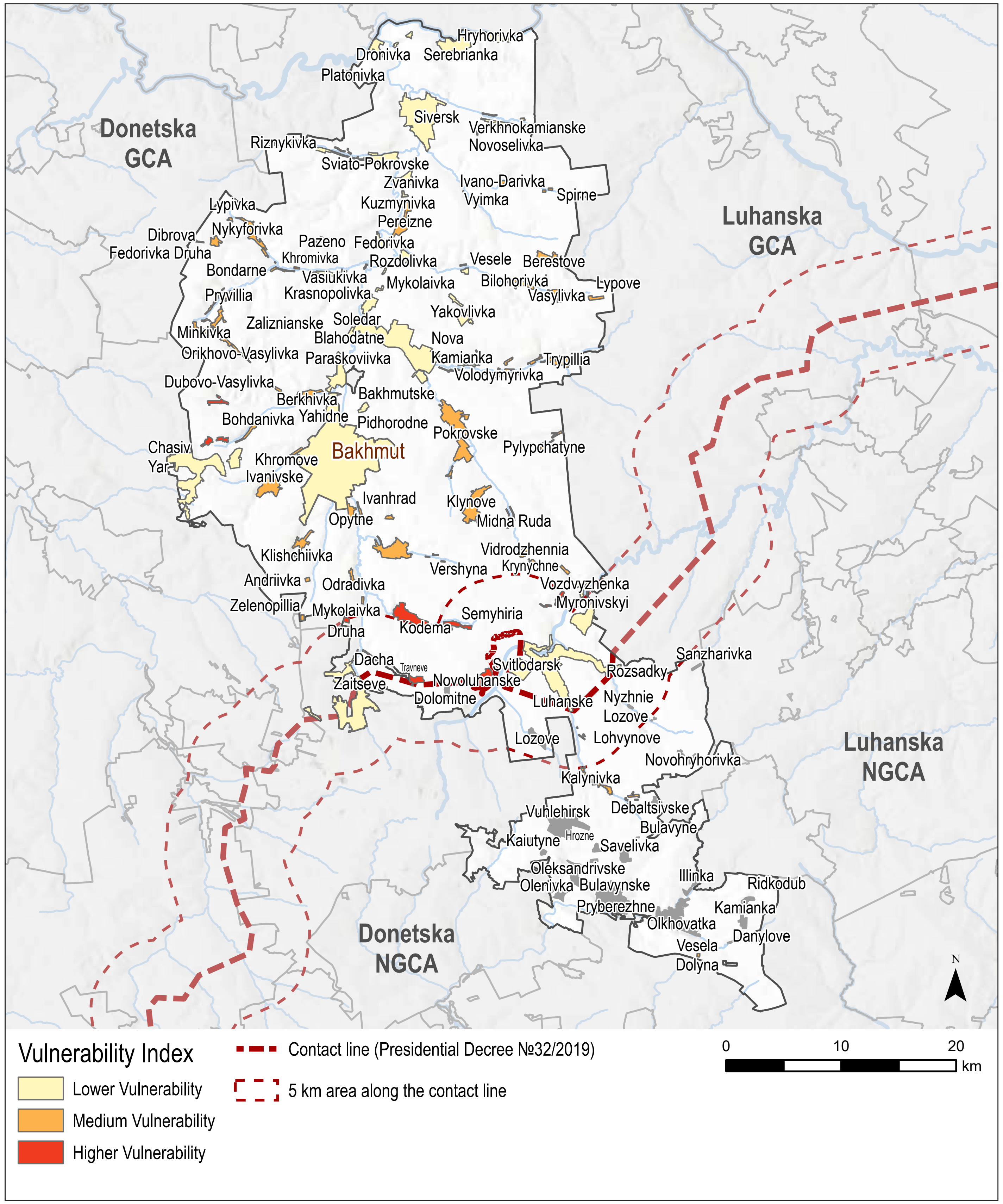
Time	>5km Rural	>5km Urban	5km Rural	5km Urban
< 1 km	5%	30%	3%	16%
1-5 km	8%	37%	1%	4%
5-20km	40%	10%	6%	8%
>20km	38%	15%	89%	62%
Don`t know	10%	8%	2%	9%

VULNERABILITY - SUSCEPTIBILITY AND COPING CAPACITY

Map 12.1 Toretsk City Council Settlement Classification from CVA Sampling Stratification



Map 12.2 Vulnerability Map



ANTHROPOGENIC MULTI-HAZARD EXPOSURE

Anthropogenic Multi-Hazard Exposure

Anthropogenic multi-hazard exposure was calculated from the combination of hazard indicators 2.1 hazardous facilities, 2.2 conflict incidents and 2.3 air pollution. The number of hazardous facilities within 2km was calculated for each settlement and are shown in Tables 13.1, 13.2 and 13.3. This includes the DEIS identified hazardous critical infrastructure facilities, tailings dams, spoil tips, waste management, and filtering stations.

There are relatively fewer hazardous facilities in Bakhmut as compared with neighbouring Horlivska Raion. They are concentrated around Luhanske and around the raion's southern boundary, whilst spoil heaps are also concentrated towards the south. The tables list the main settlements with facilities <2km as a rough indicator for human and environmental exposure. As multiple hazardous facilities/objects may have cumulative impacts on humans and the environment, the number of facilities are shown, also within 5km to indicate wider-reaching impacts.

Luhanske, Myronivskyi and Vozdvyzhenka are most exposed to hazardous facilities, with 4 located within 2km of each. Oleksandrivske has 10 spoil tips within 2km, whilst both Myronivskyi and Vozdvyzhenka each have 2 tailing ponds within 2km. It is important to note that in some cases there are multiple facilities 2- 5km from a settlement but none within 2km, excluding them from the tables. For instance, Hrozne has 11 spoil tips 2-5km from the settlement but 0 within 2km, whilst Zaitseve has 10 facilities within 2-5km but 0 within 2km.

Due to heavy industry, many settlements face high levels of air pollution. Settlements located towards the southwest and south experienced poorer air pollution, with Travneve and Olenivka having the worst based on averaged measurements from January-June 2020.

At over 200 each, Zaitseve, Dolomitne and Novoluhanske experienced the most conflict events according to 2019 INSO data and settlements located closest to the CL had the highest anthropogenic hazard exposure overall. As Map 13.1 shows, Myronivskyi, Vozdvyzhenka, Luhanske and Zaitseve are amongst the most at risk from anthropogenic hazards.

A detailed analysis of each hazardous facility, their substances, exposure, and transfer pathway is needed to highlight whether exposure would increase. To improve calculations of hazard exposure, facilities should be individually assessed to determine types and quantities of substances. The FEAT 2.0 Pocket Guide can also be applied.

Map 13.1 Anthropogenic Multi-Hazard Exposure by Settlement

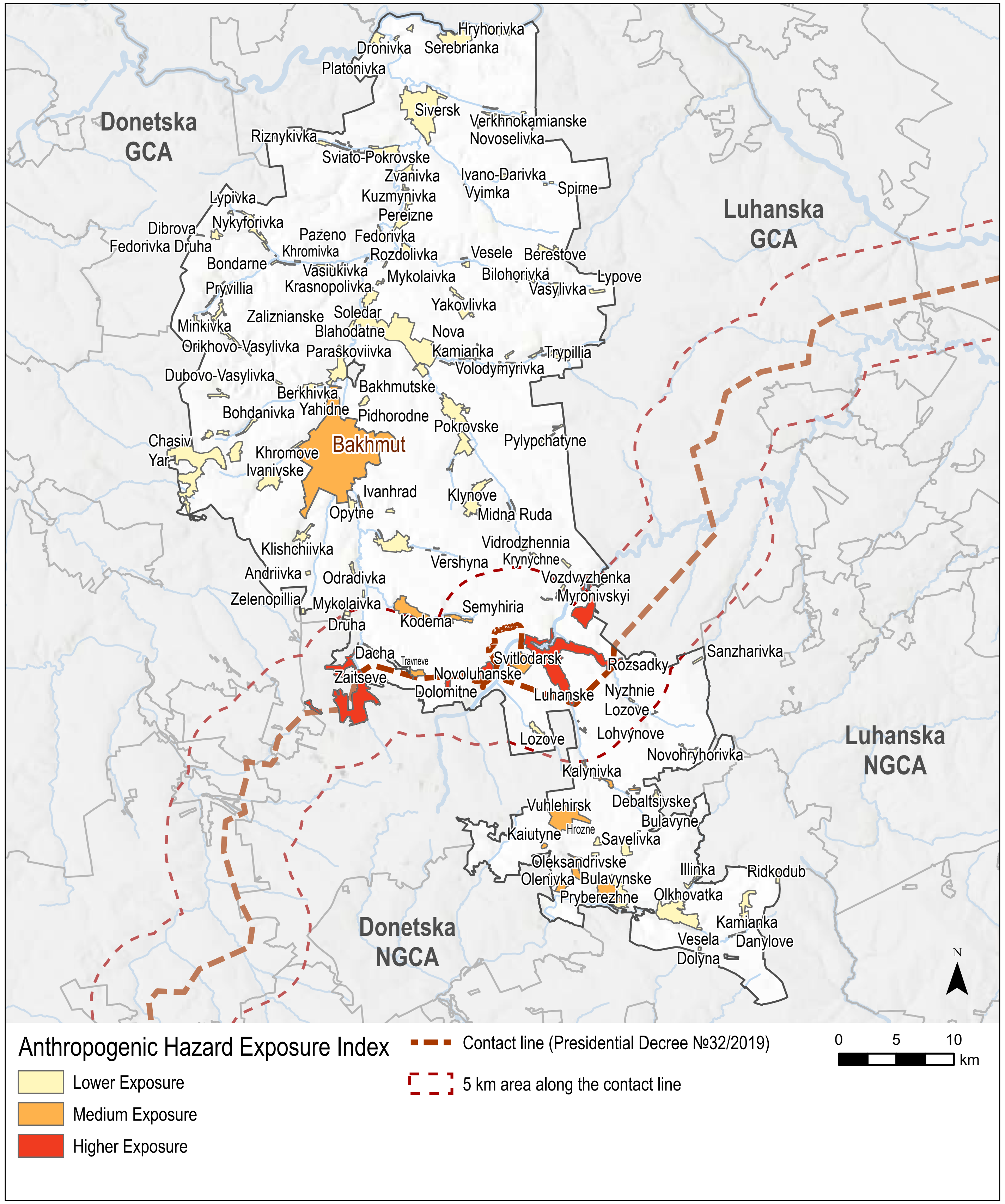


Table 13.1 Settlements most exposed to Hazardous Facilities

Settlement	Within 2km	Within 5km
Luhanske	4	10
Myronivskyi	4	5
Vozdvyzhenka	4	4
Svitlodarsk	3	5
Oleksandrivske	2	5
Olenivka	2	8
Dolomitne	2	3

Table 13.2 Settlements most exposed to Spoil Tips

Settlement	Within 2km	Within 5km
Oleksandrivske	10	18
Pryberezhne	9	17
Kaiutyne	9	15
Vuhlehirsk	8	15
Olenivka	7	24
Bulavynske	5	18

Table 13.3 Settlements most exposed to Tailing dams

Settlement	Within 2km	Within 5km
Myronivskyi	2	2
Vozdvyzhenka	2	2
Opytne	1	2
Ivanhrad	1	2
Myronivka	1	3

Natural Multi-Hazard Exposure

The natural multi-hazard exposure analysis was calculated from the combination of hazard indicators 1.1 wildfires, 1.2 heat waves and 1.3 cold waves.

Tables 14.1, 14.2, and 14.3 present lists of settlements that historically were most exposed to environmental hazards (during years 2001-2019). Rural settlements generally had the greatest natural multi-hazard exposure. The five most exposed settlements were Volodymyrivka, Zelenopillia, Pylypchatyne, Kodema and Hryhorivka. All of these settlements are classified as rural and located beyond 5km from the CL, except for Kodema which is located within 5km.

Bakhmut settlement had the highest number of fire events recorded in FIRMS data between 2001 and 2019 within a 2km radius. However, based on a combination of percentage forest cover, number of recorded fires from FIRMS data between 2001-2019, and number of INSO recorded conflict events in 2019, Chasiv Yar (an urban settlement beyond 5km of thh CL) and Zaitseve (an urban settlement <5km from the CL) may be most at risk from wild fires in the future.

As for extreme temperature, settlements to the south and east of Bakhmut settlement were more exposed to heatwaves. Zelenopillia, located to the south of Bakhmut settlement was the most exposed, experiencing an average of 32 days exceeding 37° between June and August based on observations from 2000 to 2019. As for cold waves, Platonivka was most exposed, with an average of 24 days where the temperature dropped below -15° between December and February, also based on observations between 2000 and 2019.

Natural hazards are also considered as triggers for failure of infrastructure such as power supply, water supply, heating, as well as social infrastructure which makes these hazards a significant threat to the population.

Map 14.1 Natural Multi-Hazard Exposure by Settlements

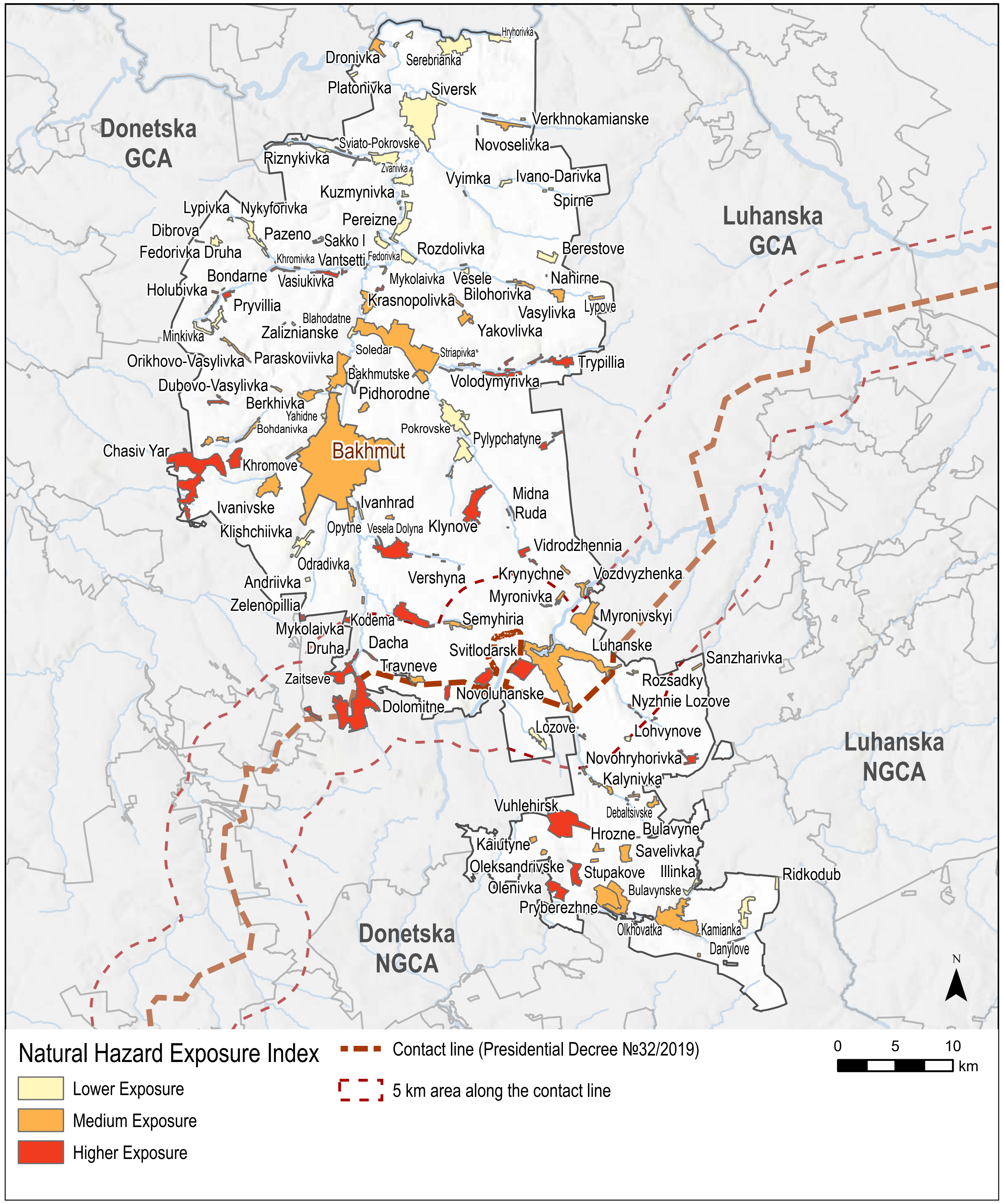


Table 14.1 Settlements with Highest Observed Frequency of Abnormally Low Temperatures

	Settlement	Mean number of days per year with cold waves
1	Platonivka	24
2	Sakko I Vantsetti	22
3	Bondarne	22
4	Novoselivka	22
5	Verkhnokamianske	22
6	Dronivka	22
7	Vasiukivka	21
8	Ivanivske	21
9	Hryhorivka	21

Table 14.2 Settlements with Highest Observed Frequency of Abnormally High Temperatures

	Settlement	Mean number of days per year with heat waves
1	Zelenopillia	32
2	Pylypchatyne	31
3	Volodymyrivka	31
4	Olenivka	30
5	Kodema	29
6	Nyzhnie Lozove	28
7	Vesela Dolyna	28
8	Holubivka	28
9	Svitlodarsk	27

Table 14.3 Settlements with Highest Observed Frequency of Fires during years 2001-2019 (within 2km)

	Settlement	Number of fires (FIRMS data)
1	Bakhmut	100
2	Luhanske	75
3	Zaitseve	70
4	Soledar	70
5	Chasiv Yar	65
6	Siversk	65
7	Riznykivka	45
8	Kalynivka	40
9	Pokrovske	30

Multi-Hazard Risk (Anthropogenic & Natural)

Multi-hazard risk was calculated based on the equal weighting of the five hazard exposure indicators: wildfires, heat waves, cold waves, hazardous facilities and conflict incidents, against the societal vulnerability indicators applied to the settlements. This provides insight not just to multi-hazard exposure, but also considers the vulnerabilities of the settlements assessed to such hazards.

Map 15.1 shows the broad pattern of overall risk to anthropogenic and natural hazards across the raion. It is clear that risk becomes higher closer to the CL, whilst settlements in the far north of the raion experience a relatively lower level of risk.

Settlements shaded in grey on the map are located in the NGCA. Because the REACH 2018 CVA did not cover this area, it was not possible to collect all of the data necessary to calculate accurate risk scores for these settlements.

The rural settlement of Novoluhanske, located less than 5km from the CL, had the highest multi-hazard risk overall. This is predominantly due to high risk of anthropogenic hazards in the settlement, mainly related to the high number of conflict events as recorded by INSO, as well as high natural risk due to relativley high exposure to extreme weather and risk of wild fires. The settlement is also the most vulnerable in the raion, increasing the overall risk.

Table 15.1 lists all of the settlements in Bakhmut Raion, ranked by their overall risk to anthropogenic and natural hazards. Kodema, Travneve, Zaitseve, Semyhiria, Luhanske, Myronivka, Mykolaivka Druha and Dacha were also amongst the most at risk out of the 113 settlements in the raion.

These most at risk settlements are all located within 5km of the CL, indicating the disproportionately high anthropogenic risk these settlements experience due to proximity to the conflict.

Additionally, most of the aforementioned settlements are also rural and this strata has the highest vulnerability overall due to reasons such as poor access to key services, vulnerable head of households, reliance on agriculture and other factors as summarised previously.

The most at risk urban settlement was Zaitseve, which suffers from high exposure particuarly to anthropogenic hazards, despite having relatively lower vulnerability than rural settlements the same distance from the CL. This is followed by Luhanske, which also has a relativley lower vulnerability than rural settlements.

Settlements beyond 5km from the CL generally had lower multi-hazard risk and the rural settlement of Kuzmynivka had the lowest risk overall. Settlements far from the CL that were at a higher risk, such as Dronivka, generally faced higher risk to natural hazards rather than anthropogenic hazards.

Siversk, in the far north of the raion, was the least at risk urban settlement. This is mainly due to low vulnerability and low overall exposure to hazards. However, there is a relativley high wildfire risk here, so multi-hazard risk should not be considered alone as settlements may have an elevated risk only to specific hazards.

Key findings

1. Settlements closest to the CL have the highest overall multi-hazard risk. This is due to high frequency of conflict incidents and high vulnerability.

2. Rural settlements close to the CL faced the most vulnerability, increasing their overall risk.

3. Multi-hazard risk must be considered in parallel with specific hazards that might occur in a settlement and vulnerability to those specific hazards.

Map 15.1 Multi-Hazard Risk By Settlements

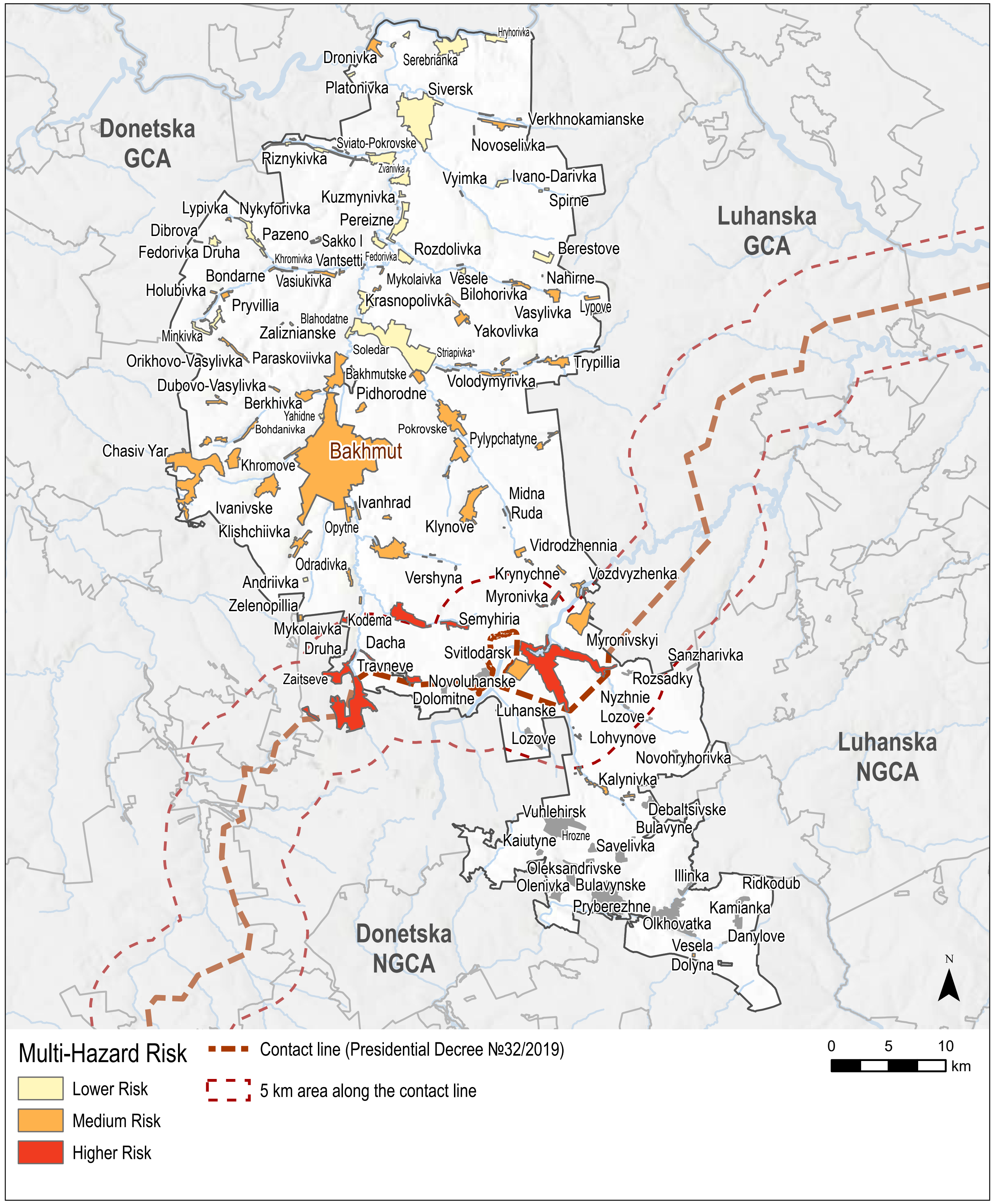


Table 15.1: Settlement Multi-Hazard Risk

Settlement	Population	Multi-Hazard Exposure	Vulner-ability Index	Multi-Hazard Risk
Novoluhanske	3830	12.28	25.71	3.16
Kodema	590	11.09	23.97	2.66
Travneve	286	10.33	24.84	2.57
Zaitseve	3459	13.70	18.35	2.51
Semyhiria	347	10.26	23.82	2.44
Luhanske	2323	12.46	18.81	2.34
Myronivka	58	9.08	23.80	2.16
Mykolaivka Druha	7	8.88	24.33	2.16
Dacha	39	8.89	24.19	2.15
Vozdvyzhenka	335	10.45	18.80	1.97
Zelenopillia	316	9.66	19.40	1.88
Hryhorivka	92	9.30	20.14	1.87
Myronivskyi	8045	10.35	17.94	1.86
Svitlodarsk	12164	10.25	17.84	1.83
Volodymyrivka	1121	9.62	18.85	1.81
Pylypchatyne	70	9.42	19.23	1.81
Kalynivka	112	9.02	19.62	1.77
Bondarne	43	9.17	18.91	1.74
Vesela Dolyna	277	8.99	19.27	1.73
Holubivka	40	9.03	19.19	1.73
Klynove	826	9.00	19.06	1.72
Pryvillia	136	8.88	19.12	1.70
Roty	82	8.89	18.85	1.68
Khromivka	34	8.83	18.90	1.67
Vasiukivka	601	8.73	18.75	1.64
Zaitseve	1162	8.50	19.10	1.62
Nahirne	14	8.46	19.13	1.62

Settlement	Population	Multi-Hazard Exposure	Vulner-ability Index	Multi-Hazard Risk
Vidrodzhennia	278	8.57	18.88	1.62
Kalynivka	681	8.06	20.05	1.62
Vasylivka	142	8.44	19.12	1.61
Midna Ruda	9	8.48	19.02	1.61
Trypillia	194	8.44	19.02	1.61
Opytne	1983	8.22	19.42	1.60
Khromove	1054	8.02	19.78	1.59
Ivanivske	1732	8.04	19.73	1.59
Mykolaivka	16	8.22	19.17	1.58
Lypove	56	8.14	19.30	1.57
Krasnopolivka	0	8.38	18.61	1.56
Krynychne	41	8.23	18.85	1.55
Bohdanivka	97	7.75	19.98	1.55
Bilohorivka	134	8.15	18.97	1.55
Paraskoviivka	2807	8.24	18.62	1.53
Sakko I Vantsetti	3	8.14	18.72	1.52
Berkhivka	118	7.64	19.90	1.52
Mykolaivka	43	8.12	18.68	1.52
Orikhovo-Vasylivka	227	7.95	19.04	1.51
Dubovo-Vasylivka	13	7.97	18.95	1.51
Odradivka	152	7.84	19.24	1.51
Vesela Dolyna	5	7.43	19.88	1.48
Bakhmutske	784	7.92	18.62	1.47
Chasiv Yar	13999	9.06	16.06	1.46
Ivanhrad	167	7.44	19.40	1.44
Klishchiivka	512	7.29	19.50	1.42
Lypivka	6	7.38	19.26	1.42
Yakovlivka	1326	7.59	18.72	1.42

Settlement	Population	Multi-Hazard Exposure	Vulner-ability Index	Multi-Hazard Risk
Striapivka	50	7.58	18.74	1.42
Dronivka	613	7.60	18.69	1.42
Verkhno - kamianske	960	7.56	18.68	1.41
Pidhorodne	163	7.45	18.73	1.40
Bakhmut	77620	8.81	15.82	1.39
Pokrovske	1333	7.18	19.29	1.38
Riznykivka	593	7.35	18.70	1.37
Rozdolivka	740	7.27	18.73	1.36
Vershyna	24	7.13	18.92	1.35
Zaliznianske	2	7.10	18.83	1.34
Yahidne	318	6.69	19.80	1.33
Nova Kamianka	14	6.67	19.72	1.32
Serebrianka	1100	7.05	18.65	1.32
Andriivka	74	6.69	19.43	1.30
Nykyforivka	645	6.79	19.00	1.29
Minkivka	800	6.52	19.13	1.25
Soledar	11708	7.81	15.75	1.23
Novoselivka	1	6.57	18.67	1.23
Platonivka	42	6.52	18.73	1.22
Berestove	1269	6.38	19.13	1.22
Pazeno	16	6.41	18.92	1.21
Sviato-Pokrovske	542	6.47	18.64	1.21
Fedorivka Druha	84	5.92	19.25	1.14
Blahodatne	137	6.06	18.56	1.13
Fedorivka	410	5.90	18.79	1.11
Vesele	102	5.80	18.82	1.09
Dibrova	22	5.52	19.32	1.07
Zvanivka	1428	5.58	18.69	1.04
Vyimka	21	5.22	19.10	1.00

Settlement	Population	Multi-Hazard Exposure	/Vulner-/ ability Index	Multi-Hazard Risk
Hryhorivka	90	5.02	18.82	0.95
Ivano-Darivka	29	4.88	18.89	0.92
Pereizne	854	4.82	18.84	0.91
Spirne	80	4.60	19.32	0.89
Siversk	12145	4.85	15.75	0.76
Kuzmynivka	29	3.55	18.84	0.67
Dolomitne	106	12.90	/	
Vuhlehirsk	7868	9.39	/	
Kaiutyne	213	8.99	/	
Oleksandrivske	2003	9.88	/	
Olenivka	964	10.47	/	
Olkhovatka	3129	8.11	/	
Nyzhnie Lozove	11	9.10	/	
Stupakove	58	8.26	/	
Rozsadky	32	8.11	/	
Ridkodub	71	6.62	/	
Hrozne	90	7.63	/	
Sanzharivka	8	8.44	/	
Bulavynske	3786	8.80	/	
Pryberezhne	168	8.65	/	
Lohvynove	57	7.28	/	
Savelivka	825	8.15	/	
Kamianka	742	6.63	/	
Debaltsivske	679	7.73	/	
Lozove	48	6.51	/	
Bulavyne	61	6.84	/	
Novohryhorivka	475	8.84	/	
Illinka	272	6.43	/	
Danylove	12	7.70	/	

Hromada Proposed Administration

The state policy of Ukraine in the area of local self-government is based, primarily, on the interests of residents of territorial communities. The decentralization reform provides for significant and systemic changes through decentralization of power - that is, transfer of a significant proportion of power, resources, and responsibility from the executive branch of the government to the bodies of local self-government (hromadas).

According to the new prospective administrative plan, Bakhmut Raion includes five hromadas: Soledar, Siversk, Zvaniv, Bakhmut and Toretsk, as indicated in Map 16.1.

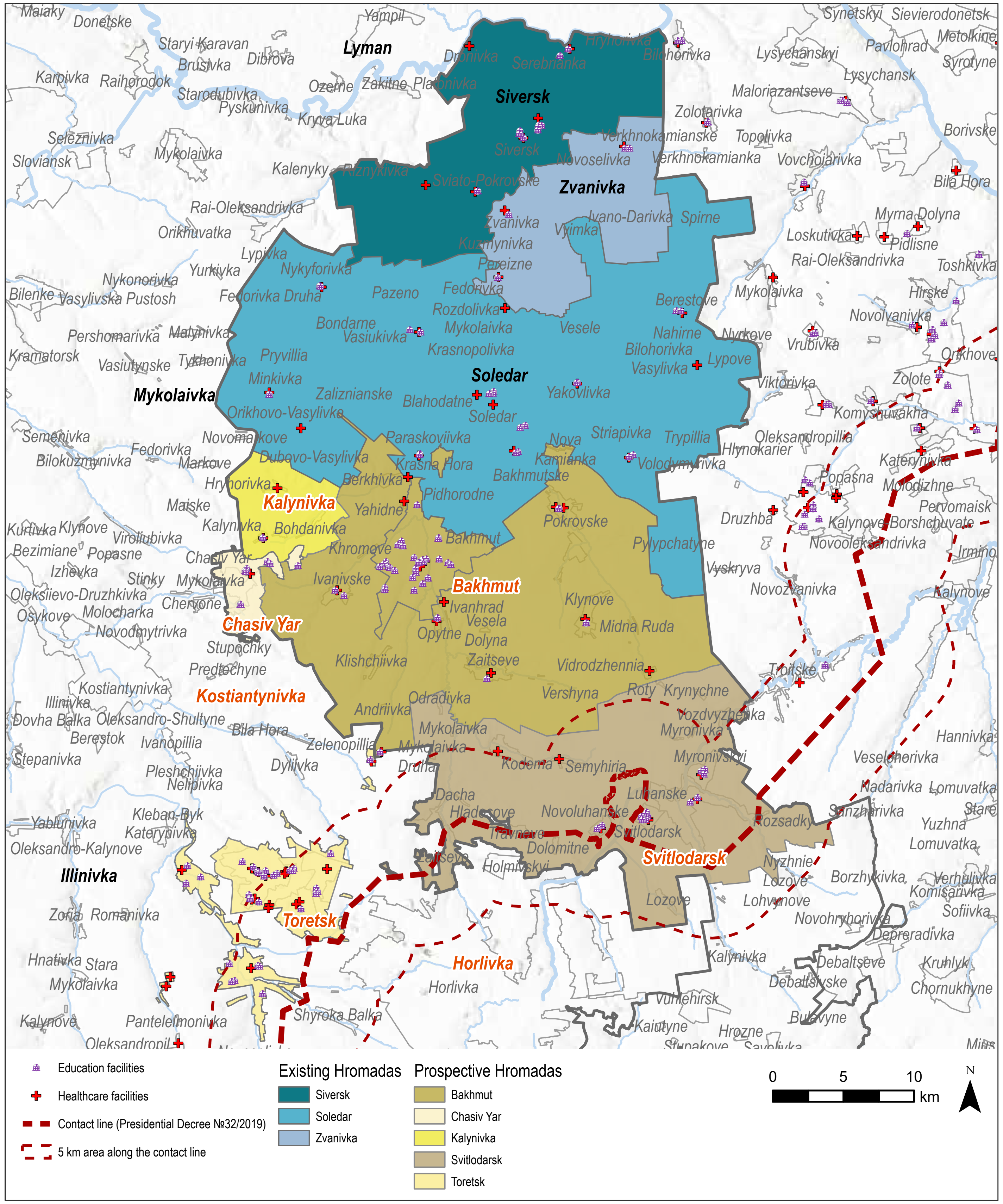
Soledar, Siversk and Zvaniv hromadas were formed between 2016 and 2017 and the first local elections were held during this period. Bakhmut hromada currenly includes Bakhmut urban council and 5 village councils.

It is proposed that Svitlodarska hromada will include 6 urban and village councils. Some of these areas, like Zaitseve, belonged to Horlivka City Council before the beginning of the conflict, but have since been divided by the contact line. Almost the whole area of Svitlodarsk hromada is located under 5km from the CL. Frequent conflict incidents, landmine contaminations and lack of transportation connections are the main challenges facing citizens of Svitlodarsk hromada.

Toretsk hromada, currently located within the boundaries of the existing Toretsk City Council is planned to become a part of the prospective Bakhmut Raion. There is no final agreement on Chasiv Yar and Kalynivka urban type and village councils; it is possible that these areas may form Chasiv Yar hromada, which is also expected to be a part of the prospective Bakhmut Raion.

Under the decentralization reform, 2 new citizen safety centers were created in July 2020 in Soledar and Siversk, maintained by SESU. The main purpose of the citizen safety centers are to provide a full range of security services. This includes a fire and rescue unit, emergency medicine units and a pyrotechnic unit, which is important due to the close proximity of these areas to the CL.

Map 16.1 Overview Map for Bakhmut Area Hromadas



To ensure comprehensive protection of the civilian population in newly created amalgamated communities (hromadas), strong inter-departmental preparedness and mitigation planning process led by a Civil Protection specialist is recommended. In line with global best practices and guidance (such as the Sendai Framework), newly created hromadas should pay particular attention to developing data-driven Disaster Risk Reduction strategies, for which this analysis can serve as a first step.

According to the new adminstrative divisions, Donetska Oblast will consist of 8 raions. However, it is important to note that 3 raions out of 8 will be located in the NGCA: Horlivska, Donetska and Kalmiusky. Map 16.2 shows an overview of the proposed raions.

Map 16.2 Overview Map of Prospective Raions

Conclusions

This ABRA for Bakhmut area aimed to analyse hazard exposure and community vulnerability to assess both natural and anthropogenic risks for each settlement in the area.

This was done using a combination of socioeconomic assessments based on a 2018 CVA undertaken by REACH and geospatial data analysis. Settlements were stratified into rural and urban, and whether the settlement was located less than or more than 5km from the CL.

It is expected that the ABRA will be used by the communities and local authorities as a background for risk management plan development that will address the local communities' vulnerability and needs to prepare and respond effectively to a range of hazards.

The study has been conducted at the sub-regional level, and relies on both locally available data, global datasets, and satellite imagery. Most of these datasets are open access and constantly updated and may be used to reproduce the analysis for other areas or time periods. Thus, this ABRA also serves as a demonstration tool for environmental and industrial risk at a local settlement level.

Community prioritization according to the level of hazard exposure and vulnerability is important for increasing the awareness about the actual risks and an essential step in building capacity to the exposed hazards.