

## SOCIO AND GEOGRAPHICAL RESEARCH

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### USING NIGHT ILLUMINATION IMAGES BASED ON REMOTE SENSING DATA FOR THE SOCIO-ECONOMIC ASSESSMENT OF A BESIEGED CITY (MARIUPOL CITY, (UKRAINE) AS AN EXAMPLE)

### ВИКОРИСТАННЯ ЗОБРАЖЕНЬ НІЧНОЇ ОСВІТЛЕНОСТІ ЗА СУПУТНИКОВИМИ ДАНИМИ ДЛЯ СОЦІО-ЕКОНОМІЧНОЇ ОЦІНКИ БЛОКАДНОГО МІСТА НА ПРИКЛАДІ МАРІУПОЛЯ (УКРАЇНА)

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Today, there are no absolutely safe places on the planet – there are more or less safe places, and the degree of risk for specific locations is constantly changing. Modern war has no front, no rear, no flanks in the conventional sense. All places become potentially vulnerable and such concepts as "territory", "border" become relative. Especially today, cities and their infrastructure are the main problem area of modern wars, since they turn into battlefields with an extremely limited and densely populated space. Initially, cities arose as a means of population protection. With the historical changes, cities have also been evolving in time and space, but their main protective function still remains the same. The analysis of various data in the field of urban protection showed that the problem of the impact of military conflicts, in particular, active hostilities, on urban space has not been well studied. In recent decades, remote sensing data have been increasingly used in scientific research. Such data is especially useful in case of military conflict or invasion, when other methods are limited. The results of relevant studies can be found in works [1–3]. It should be noted that hostilities are often accompanied by environmental risks, which have been studied using remote sensing data for a long time. Currently, there are still no relevant works on operational monitoring of socio-economic processes during a large-scale Russian invasion of Ukraine.

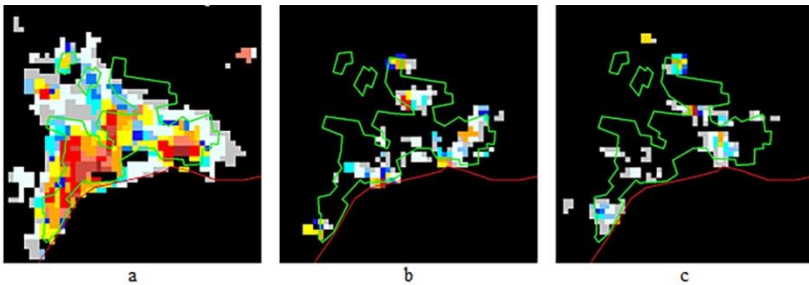
The purpose of the work is to consider the possibilities of using satellite information to study the urban area, in particular, the possibility of using remote sensing data about night illumination from the VIIRS radiometer onboard the Suomi NPP satellite to assess the destruction of cities during active hostilities. As a result of the study, the socio-economic assessment of the besieged city has been done. Ukrainian city of Mariupol has been selected as an example.

The large-scale invasion of Russian of Ukraine took place on February 24, 2022. It started with massive indiscriminate rocket fire that hit many infrastructure facilities, including not only military facilities, but also residential areas of many cities.

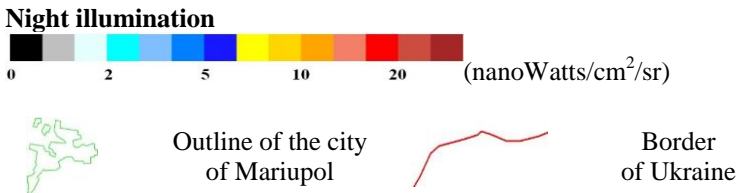
The city of Mariupol was the place of the fiercest fighting during the invasion. This Ukrainian city is located in the Donetsk region on the shores of the Sea of Azov at the mouth of the Kalmius River. The city was a significant industrial center of the country with a population of 431,859 residents as of 2021 [4]. During the Russian invasion of Ukraine, the city was almost completely destroyed by the Armed Forces of the Russian Federation. Since May 20, 2022, the city is under full occupation.

The methodology for determining the destruction caused by military actions for the city of Mariupol was carried out as follows. The quantitative criterion for the economic activity of the territory is the proposed

quantitative indicator of the total intensity of lighting (TIL) [5]. TIL is the sum of the illuminance values of all pixels for the territory of the city of Mariupol for different months of the study. The Suomi NPP/VIIRS satellite has a spatial resolution of 450 meters and provides monthly values of nighttime illumination in nanoWatts/cm<sup>2</sup>/sr. Monthly data of night illumination from the Suomi NPP/VIIRS satellite for the globe is divided into 6 scenes. The territory of Ukraine is located in scene 75n060w that has been selected for study. Data of night illumination for February, March and April 2022 have been used. The data processing has been done using a specialized software for processing satellite images (Erdas Imagine). At the first stage, using the *SubSet* function and area of interest (\*.aoi) file, the territory of Ukraine has been selected from the globe scene for three months of 2022. At the second stage, a 3-channel image has been formed, where the first channel corresponds to night illumination for February 2022, the second channel – for March 2022, and accordingly, the third one – for April 2002. At the third stage, the coordinate system of the 3-channel image has been converted from WGS 84 in degrees into UTM WGS 84/zone 36 in meters. At the fourth stage, the city of Mariupol has been identified and the territory has been ranked according to the degree of illumination (Fig. 1).



**Fig. 1. Night illumination of the city of Mariupol according to data from the Suomi NPP satellite in a) February; b) March; c) April**



The result showed that in February 2022, the total intensity of night illumination for the city of Mariupol was 5941 (nanoWatts/cm<sup>2</sup>/sr), while in March and April this value dropped to 879 (nanoWatts/cm<sup>2</sup>/sr) and 490 (nanoWatts/cm<sup>2</sup>/sr) respectively. Thus, night illumination decreased in March by 6.76 times compared to February, and by 12.13 times in April. This can be clearly seen in Fig. 1, which showed that in March and April, according to night illumination data, the city as an urban agglomeration actually ceased to exist.

Therefore, the information obtained from the SNPP/VIIRS satellite data about night illumination can be used as operational independent monitoring of changes in the socio-economic situation of the city during active hostilities. It also could be an additional source of data about city population in order to clarify the humanitarian situation in the war zone.

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