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Evaluating the Impact of Armed Conflict on Agricultural Sector in Ukraine through Remote Sensing and Machine Learning

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The war in Ukraine, which has been going on since February 2022, has dealt a severe blow to the country's agricultural sector. Millions of hectares of agricultural land have been destroyed by shelling, explosions, and landmines. This has raised concerns about food security in the international community, as Ukraine was a leading producer and exporter of wheat, maize, barley, and sunflower oil before the war. In order to determine the extent of the damage and develop the necessary recovery measures, as well as to formulate effective resource management strategies to ensure the sustainability of the agricultural sector, it is critical to accurately assess and locate the damaged agricultural areas.

Remote sensing, with its advantages in speed, coverage, and objectivity over ground-based methods, combined with machine learning, offers opportunities for the automatic detection of damaged fields across the entire territory of Ukraine and tracking the dynamics of damage development almost in real-time. This research demonstrates the potential of remote sensing and machine learning in detecting and analyzing damaged agricultural fields in Ukraine because of the military conflict.

We utilize freely available two-week composites from the Sentinel-2 satellite with a spatial resolution of 10 meters. The search for damaged fields is conducted in the cloud environment of Google Earth Engine using a random forest binary classifier trained on a manually collected sample by three independent experts. The input parameters for the classifier include static indicators (minimum, average, maximum, variance) of two spectral bands (B2, B3) and two vegetation indices (NDVI and GCI), which have been experimentally found to be the most informative for detecting field damage. Additionally, within the classified damaged fields, we identify local damages using an anomaly detection method. This involves measuring the deviation of values of individual pixels from the mean value of all pixels within a specific field in the spectra of the above-mentioned bands and vegetation indices.

The developed classifier achieves an accuracy of 0.9 for both recall and precision. The anomaly analysis method proves sensitive to the vegetation period and the geographical location of the study area. However, with careful selection of the threshold coefficient, the developed method

demonstrates sufficiently accurate results and allows the recognition of craters with an estimated area >50 m².

The results highlight substantial losses to Ukraine's agricultural sector due to the war. It was determined that from the beginning of the conflict until December 4, 2023, more than 1.5 million agricultural fields in Ukraine were damaged, constituting approximately 5.65% of the total sown area. The most affected crops were wheat (489,529 ha or 5.78% of the total cultivated area for this crop), sunflower (115,358 ha or 1.56% of the cultivated area), maize (61,123 ha or 1.2%), and rapeseed (42,783 ha or 2.65%).

Our methods are applicable to large territories for detecting damages to various agricultural crops. The research will be valuable for assessing and restoring damaged lands, as well as for developing strategies for adaptation and resilience of the agricultural sector to other similar crisis situations.