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Of War and Hunger: The Russia-Ukraine war's impact on soil degradation in Ukraine and its effect on the malnutrition of Ukrainian peoples.

Introduction

What would you do if your country was at war and the very thing growing your food, supporting your home, and stabilizing life in your country was under attack? This question is not hypothetical for Ukrainian families. For the past 11 years, the country of Ukraine, located in Eastern Europe, has been in a war with Russia that has devastated wildlife, infrastructure, travel, the health of the citizens, and the health of the soil. As a part of our ecosystems, our economy, and ourselves, soil health impacts every living thing on the planet. This paper will explore the question of how the war between Russia and Ukraine affects soil health in Ukraine.

Background on the country and family

Ukraine operates under a unitary republic in which a presidential-parliament system is employed, meaning that a president is directly elected by the public for a term of five years. The elected president appoints a prime minister who the parliament confirms. The current president of Ukraine is Volodymyr Zelenskyy, an independent, and the current prime minister is Denys Shmyhal, another independent politician (United States Department of State). The population of Ukraine is 38 million (2024 data from the World Bank). 29.91% of the population lives in rural communities (2023 data from Macro Trends), while 70.1% lives in urban areas (2023 data from Trading Economics). The average Ukrainian household size is 2.5 people (ArcGIS 2022).

The majority of Ukraine resides in a temperate climate zone, while the southern coast of Crimea has a Mediterranean climate. Geographically, Ukraine is majorly made up of flat plains, with some mountain ranges in the west, the Carpathian Mountains, and some in the south, the Crimean Mountains. Ukraine also has the Dnieper River that runs through the central region of the country, spanning a staggering 1,367 miles (Ukraine.com). The country has an annual mean temperature of 7-9 degrees Celsius and an annual mean rainfall of around 500-600 mm. Ukraine experiences warm summers and cold winters, with most of its precipitation occurring in June and July (Climate Change Knowledge Portal 2021). Out of the 60.3 million hectares of land in Ukraine, 42.5 million are being used for agricultural cultivation (The FAO). Wheat, corn,

and sunflower are the bulk of Ukraine's agricultural exports, with Ukraine accounting for 50% of the world's sunflower oil production alone (European Council of the European Union). Most family farms within Ukraine average a size of around 50-100 hectares (Transnational Institute) and are considered small farms. An average-size farm is 514 hectares, while large corporate farms in Ukraine can reach up to 510,000 hectares (World Bank).

Most jobs in Ukraine take place in the informal sector, including jobs such as basic manufacturing and agriculture (World Bank 2013). The average wage of a Ukrainian household is USD 2,470 annually (CEIC Data 2021). An estimated 7.3 million Ukrainian citizens are believed to be food insecure (April 2024, IFPRI). Most Ukrainian families obtain food from growth on their farms or through provided government assistance programs. As many Ukrainians are on the frontlines of war, food rations have been put in place by the government in markets to try to ensure that all citizens can access some amount of food (World Food Program USA). The typical Ukrainian diet consists of dishes made from meats, vegetables, fruit, and mushrooms. Popular ingredients include potatoes, cabbage, and beets The most nutritious foods available to Ukrainians are beets, cabbage, buckwheat, and potatoes. Ukrainian families typically cook their food through shared or home appliances by boiling, stewing, or baking.

Ukrainians have access to free health care; however, there are many barriers to accessing it. Internally displaced persons within Ukraine struggle to find clinics and hospitals and therefore typically have more unmet medical needs. Citizens living near the frontlines of war face difficulties accessing health care due to the destruction of hospitals in their towns. Those living in rural areas and socially vulnerable groups also face disproportionately less access to health care (WHO). Ukrainians should theoretically have access to schooling and higher education; however, the war in Ukraine is currently disrupting schooling and disproportionately affecting children, creating a crisis in education (UNICEF). Most infrastructure in Ukraine, such as clean water, electricity, cell phones, and services, has been compromised due to the war. Transportation in Ukraine is made through trains, boats, cars, and planes but is very limited and highly inaccessible near the forefront of the war in the country (UkraineInvest).

Challenge and impact

To quantify the issue of soil erosion within Ukraine, I used Google Earth Pro to gather satellite imagery of Ukraine in 2013 before the war began between Russia and Ukraine and in 2020, 6 years into the war. I then created a stack of these images using ImageJ. I then set a scale of 300 km to the stack image and created an initial threshold for each separate image. After creating my initial thresholds, I created a new threshold to analyze the total change in soil coverage within the country. My results showed 677305.403 kilometers of healthy soil in 2013 before the war started dropping to a staggering 654669.885 kilometers of healthy soil in 2020, 6 years into the war. This shows a dangerous 3.4% of degraded land before the full-scale invasion of Ukraine by Russia in 2022 even occurred. The issue of soil degradation within Ukraine has been classified as severe and widespread by Ukrainian Authorities with over 20% of Ukraine's

agricultural land being affected and over 500 million tons of soil being lost annually due to erosion (WorldBank). These trends are continuing to worsen as time progresses and the war continues to destroy more Ukrainian land.

The soil erosion problem within Ukraine affects all citizens however it disproportionately affects those living in the frontlines of war. It directly poses most issues to rural populations as they are mostly in the agricultural sector and rely on their home farms as a food source as well as a source of income. Men tend to encounter more direct economic consequences due to their presence in mechanized farming (WorldBank). Urban populations also feel the effects of the soil degradation issue just less directly. Urban populations see the rise of food prices and reduced crop availability which also leads to hunger in some urbanized areas in the country. Southern and Eastern Ukraine experience the highest levels of soil erosion from intensive agricultural practices, climate, and war combined (MacroTrends). Displaced peoples have also been forced to relocate to rural areas where soil erosion is prevalent and they usually tend to have less access to tools or knowledge necessary to help them navigate the issue. Indigenous groups in the Carpathian region of Ukraine are also disproportionately affected as they rely on traditional farming practices and are facing challenges adapting to new cultivation methods in such an ecologically fragile area (WDI). The increase of soil erosion also poses an issue to the environment through the sediment pollution of waterways in the country, and removal of access to primary production causing troubles within trophic schemes, less access to carbon sequestration and feedback loops within the soil from poor nutrients and structure (WHO).

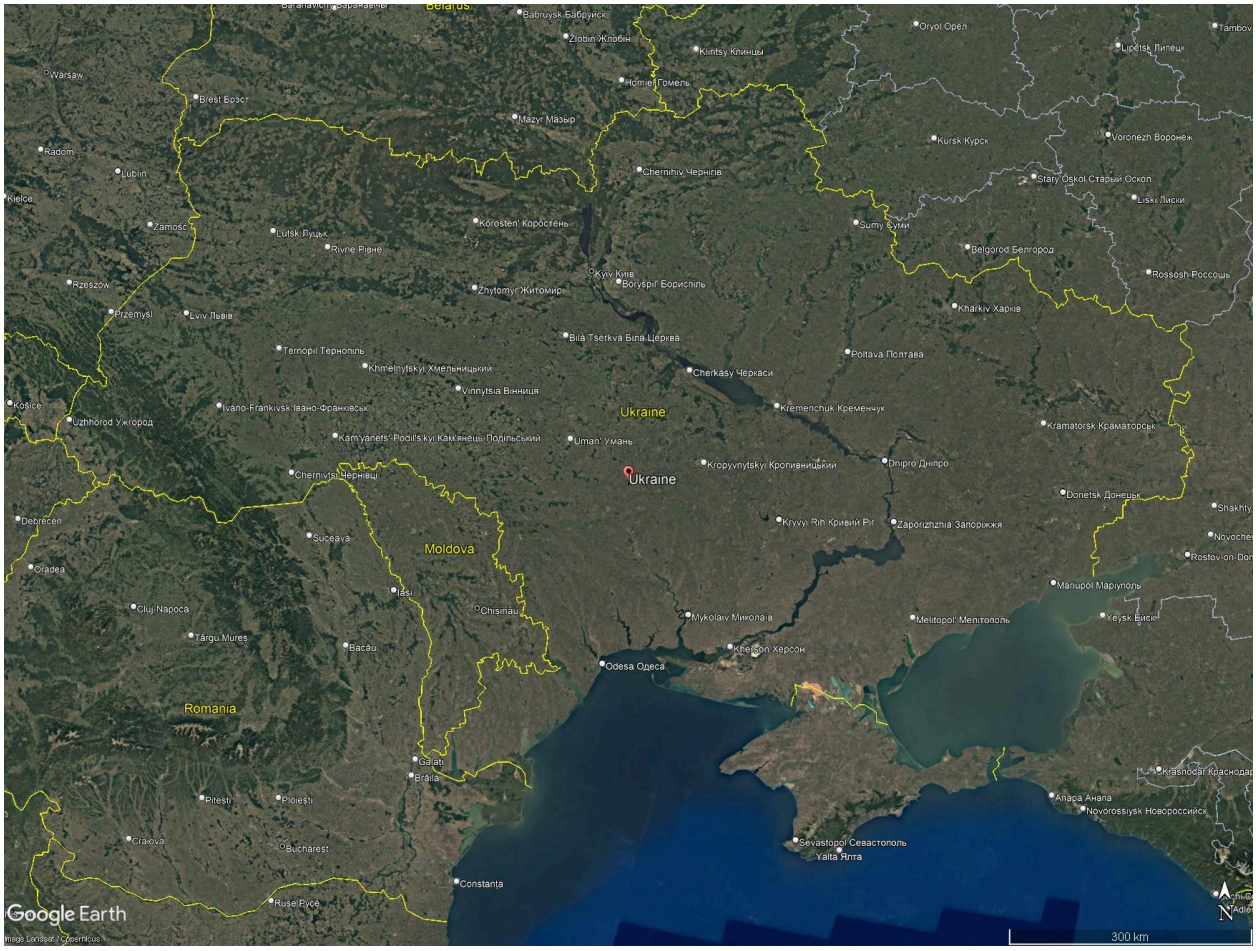

Figure 1. Ariel imaging of Ukraine taken by Google Earth in 2013 (GEP)

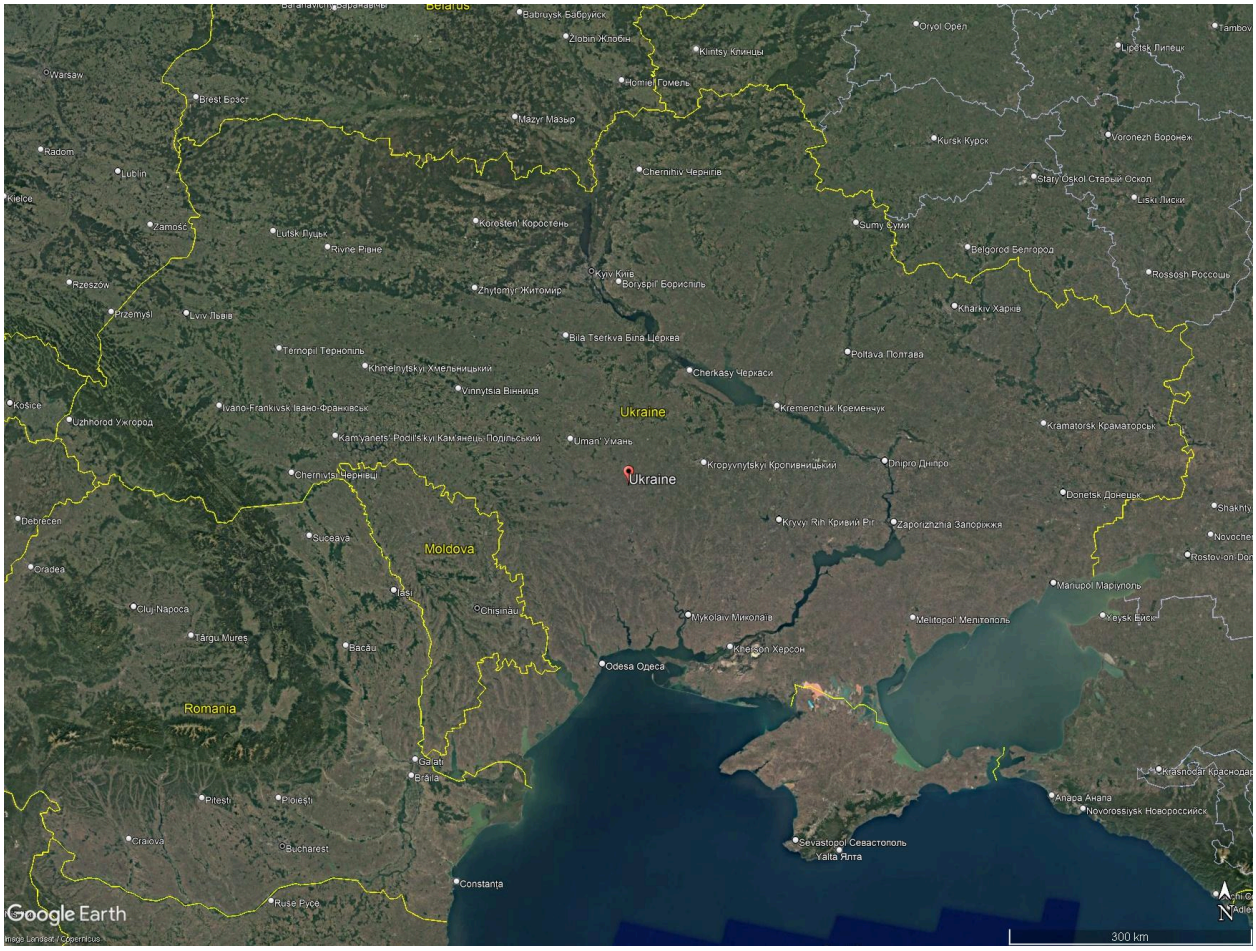

Figure 2. Ariel imaging of Ukraine taken by Google Earth in 2020 (GEP)

Table 1. Calculated threshold results showing differences in measured soil health in Ukraine between the years 2013 and 2020 (ImageJ)

	Area	Mean	Min	Max
1	677305.403	77.978	0	255
2	654669.885	83.001	0	255
3	30.292	68.316	59	71
4	19.128	65.000	59	71

Exploring solutions

Based on this research an idea for short-term solutions to Ukraine's soil degradation problem could be implementing soil-stabilization techniques such as polymers and organic mulches. A long-term solution could look like creating wetlands in low-lying areas to act as a

natural sediment trap or transitioning to low/no-till agriculture. The solution of implementing soil stabilization techniques would not immediately solve the issue of soil erosion in a long-term sense however it would allow for the short-term growth of crops to solve the hunger issue for parts of Ukraine. One downside of this solution is that it may not be affordable for the families who need it the most. The long-term solution of creating wetlands in low lying areas of the country to act as a natural sediment trap would allow for cleaner drinking water as well as prevent water erosion. This would in theory be a good solution however Ukraine is almost entirely level plains with very few low-lying areas meaning that the reaped effects of this solution would be disproportionately felt by the country's citizens. Transitioning to low/no-till agriculture is a long-term solution which will allow for the soil to remain stable naturally with less degradation from agricultural practices. This will allow the soil to grow stronger and allow crop growth. This will also decrease sediment pollution within waterbodies which will help give Ukrainians access to clean water for drinking, cooking, cleaning etc.

So far to address their soil degradation issue, Ukraine has implemented Rewilding which means allowing nature to take over extremely degraded areas. (The conflict and environmental observatory). Ukraine has also practiced demining, Soil detoxification, and loosening compacted soil. (Science Direct Filho 2024) Rewilding has had the impact of restoring soil health in rewilded areas. Efforts have also contributed to restoring floodplains in the Danube Delta in Ukraine. (Rewilding Europe) Demining has protected Ukrainian citizens from active mines exploding and damaging their physical health. However, this has also damaged the soil from increased chemical waste and soil displacement. Soil detoxification has allowed for soil health to renew in certain areas by removing contaminants but has also been expensive and is a very long process so it hasn't had a drastic impact on Ukraine. Loosening compacted soil allows for aeration in the soil which allows the soil to gain nutrients such as water and organic matter easily which are both essential for soil health however the maintenance costs have been high and also contributed to the erosion of Ukrainian soil. Ukraine has a naturally fertile soil type called Chernozem which helps combat major soil erosion but aside from their natural strengths, Ukraine is home to specialized soil research institutions and grassroots efforts that are helping to maintain soil health within the Country.

Aside from Ukraine, Neighboring countries are also feeling the effects of the Ukraine-Russia war on their soil health. Poland has experienced soil contamination and has addressed this through Reforestation programs, Refugee Integration and the use of Best Management Practices. Moldova is also feeling the effects of the war on their soil health and has community-based efforts that are working to restore agricultural fields. While community and grassroots efforts to reforest and restore land are great ways to reduce soil erosion and restore health to the land, they are less feasible solutions for Ukraine at the moment because they require those who are already physically and mentally stressed by the exacerbated effects of the ongoing war to take responsibility for an issue that they didn't cause nor have the time or materials to help with.

Recommendation

Looking back at the data, the best feasible solution to the soil erosion problem within Ukraine is implementing low-till and no-till agriculture within the country. One way to implement this and ensure that this would work would be for the government of Ukraine to send out a Public Service Announcement and ask Ukrainian citizens with personal farms or corporations with farms in Ukraine to use no-till methods in their agricultural practices in exchange for subsidies. This would incentivize citizens to participate in the action of no-till as well as provide money to citizens who have had affected finances from the effects of the war. Aside from human benefit, this would also allow the soil to naturally restore itself to its uncompacted state reducing erosion and allowing it to gain nutrients through its natural pores. One issue with this approach is the fact that even with the implementation of better agricultural practices such as no-till, the war will still happen causing stress to the environment and ultimately the soil will not heal as war continues to occur. This being said, it is better to do something and take action rather than watch and wait as the problem continues to get worse.

Because till agriculture is the most prominent type of agriculture in Ukraine and most agricultural land uses till practices, it would be a difficult switch for some citizens who do not have the education on how to utilize and execute no-till methods. With government help and grassroots efforts, these citizens could learn to embrace no-till and its benefits. To fund the subsidies, the Ukrainian Government would need to set aside money to give these subsidies to farmers. The government would also need to decide based on their resources how much they would give and create administrative procedures for dispersing the funds. The soil research institutions and grassroots efforts that were previously mentioned in Ukraine can not only monitor this program to see its impact but also promote it and find ways to expand on it through ways like advocating for subsidies on other Best Management Practices which would help advance the impact of the solution. This recommendation is feasible currently but will become more feasible as time progresses due to Ukraine's efforts to grow and strengthen its economy meaning that the government will have enough money to give these subsidies to Ukrainian citizens.

Conclusion

As the war in Ukraine tends to worsen we have discovered that soil health does as well. We see how it not only causes hunger, poverty, and tensions among the citizens of Ukraine but also harms the natural environment in the country as well. To save Ukrainian citizens and Ukrainian soil the country must act and they must act now. The implementation of low/no-till agriculture will allow the soil to replenish itself without intensive anthropogenic influence.

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