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THE EFFECT OF MILITARY ACTIONS ON THE DYNAMICS OF THE USE OF AGRICULTURAL LAND AND THE STATE OF THE SOIL COVER

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Abstract. *The topicality of the topic is due to significant changes in the state of the components of the environment, namely the soil cover, and the use of agricultural land under the influence of the consequences of military operations in 2022-2023. There is a need to assess the scale of changes in the environment, primarily the soil cover, as the most disturbed as a result of hostilities, under the influence of these*

factors, determination of their respective scales, spatial localization and environmental and legal consequences. Due to a full-scale invasion in 2022, a significant part of highly productive agricultural lands of Ukraine turned out to be temporarily unsuitable for agricultural production. Common classifications both by factors of influence and by groups of soil cover indicators, which have deteriorated as a result of military actions, need to be supplemented and clarified, for example, in our opinion, the concepts of ecocide and infrastructure violations should be added, in particular in relation to agricultural production.

The use of indicators of soil condition, monitoring of pollution, disturbance of the cover and the development of degradation processes according to operational data through the use of geoportals, dashboards and other means of public access to open data plays a particularly important role in the context of the impact of the consequences of military actions on the soil cover, prospects for agricultural production and in generally on the quality of society's life.

Key words: *agricultural lands, soil cover, soil degradation, dynamics of land use, military operations.*

Topicality. The issue of territorial organization of the agricultural land use system is one of the key conditions for sustainable development (UNEP, USDA, 2022-2023) [19, 24]. However, due to a full-scale invasion in 2022, a significant portion of Ukraine's agricultural land has become temporarily unsuitable for agricultural production.

As a result of military operations, a large part of the territory of Ukraine, including agricultural lands, is contaminated with explosive objects, which makes these lands unsuitable for economic use and also requires a very significant time to return them to a proper state suitable for agricultural production. It should be noted that the concept of "military operations" is broader than the concept of "combat operations" and includes it. There is an urgent need to conduct an inventory of disturbed agricultural lands, both those used directly and indirectly in agricultural production, and those used in variety testing and research purposes.

According to the Project of the Recovery Plan of Ukraine (2022), such works will be divided into several directions: "operational monitoring of unused agricultural land, tracking of the dynamics of withdrawal and introduction of land plots into agricultural use; accounting, inventory, systematization and updating of data" (namely, such indicators as the area of plots, type of land, classification units of soil cover, agrochemical indicators, cultivated agricultural crops, dynamics of crop seedlings, etc.) [12].

Assessing the impact of military processes on the domestic agricultural industry is a complex and lengthy process, especially since its methodology is not established. Since the Second World War, there has not been a similar example where a country with such an important agricultural sector for the world market as Ukraine suffered as a result of hostilities [15]. The most similar to the comparison is the military conflict in Syria, where significant agricultural losses have been recorded by United Nations experts. UNEP conducted an assessment of the post-war reconstruction of Albania [20], which also cannot be compared with the current conditions in our country. "In 2011, the country's agricultural gross domestic product was about $49 billion, or 20% of the total GDP ($252 billion). In 2017, the Food and Agriculture Organization of the United Nations (FAO) estimated the total financial cost of damages and losses in the agricultural sector for the period 2011–2016 at about $16 billion, equivalent to more than a third of Syria's GDP in 2016.” [15]. Nevertheless, it is difficult to compare the scale of agriculture in Ukraine and Syria, as well as their role on the world food market. According to FAO, "the total volume of agricultural exports of Syria in 2010 amounted to $2.55 billion compared to $22 billion of Ukraine in 2020." [15].

In our opinion, demining the territory occupies one of the most important areas among the areas of restoration of disturbed agricultural lands of Ukraine. According to the estimates of the NGO "Ukrainian Association of Deminers", 82,525 square meters. km are contaminated by land mines of various types, and without demining and remediation, the return of agricultural production to these lands is impossible.

According to FAO (2022), the cost of demining in Croatia was about 1.25 euros per 1 square meter. km, the cost of destroying one stacked anti-personnel mine is EUR 0.56. Taking these costs into account, the cost of a demining campaign in Ukraine may cost $10 billion [15]. Since our country has joined the UN Land Degradation Neutrality Target Setting Program, conducting such an analysis both at the national and local levels is relevant and extremely necessary [1].

The purpose of the study is to consider the typology of violations of the soil cover of Ukraine as a result of hostilities, to analyze the means that allow the analysis of such violations and to assess the impact of the consequences of military actions on the dynamics of the use of agricultural land in Ukraine.

Analysis of recent research and publications. Hostilities since the full-scale invasion of Ukraine have reduced agricultural production and largely blocked food exports. At the same time, according to USDA's "Global Report on Food Crises 2022" [24], "in 2021, Ukraine and the Russian Federation accounted for the main shares of world exports of wheat (33%), barley (27%), corn (17%), and sunflower seeds (24%), and sunflower oil (73%)" [18].

In particular, R. Vozhegova and others [22] were engaged in the study of the impact of military operations on agricultural lands and the state of the soil cover in Ukraine. Yu. Zaitsev [5], A. Kondratenko [7], V. Polozentseva [10], N. Makarenko et al. [19], A. Terebukh [13], R. Tretyak [14], T. Yakymenko [15], focusing mainly on issues of environmental damage to nature use.

Results and discussion. In Ukraine, all major types of soils were affected by armed aggression — from turf-podzolic soils in Polissia to chestnut soils in the south, but black soils were the most affected, especially ordinary and southern soils, which are constantly at the center of active hostilities.

Overall, in the world in 2021, out of 53 countries and territories experiencing food insecurity, 36 countries depended on Ukrainian and Russian food exports: more than 10% of total wheat imports, including 21 countries facing a serious food crisis (among them countries such as Yemen, Nigeria, South Sudan). In particular, the entire region of East Africa receives 90% of its wheat imports from the Russian

Federation (72%) and from Ukraine (18%). "In May 2022, the UN's World Food Program expressed concern that reduced food exports, exacerbated by the war in Ukraine, would increase the number of undernourished people to 8-13 million in 2023." (According to uwecworkgroup, [18]).

"In the developed world, the development of a system of integrated assessment of the state of land and the dynamics of soil cover changes has long attracted the attention of scientists, especially in connection with the challenges of recent decades, related to global climate changes and the problem of providing food for the world's population" (2030 Agenda for Sustainable Development , [21]). The same approach should be used to assess violations of Ukraine's soil cover as a result of hostilities, and to analyze such violations and assess the impact of hostilities on the dynamics of the use of agricultural land in Ukraine.

Works on such an assessment are usually transmitted using a system of indicator indicators that take into account a complex of factors and provide ample opportunities for accounting and qualitative and quantitative assessment with a reflection of the dynamics of changes in the case of various development scenarios [8]. A number of authors (in particular, Wessels K.J. et al. [23, 24]) consider the data of remote sensing of the Earth as a reliable source of operational information regarding certain indicators of soil degradation, in particular as a result of processes of erosion, pollution, disturbance of the fertile soil layer, dehumification, etc. [6] .

"The United Nations Convention to Combat Desertification (UNCCD) defines land degradation as "the reduction or loss of biological or economic productivity of crops grown without irrigation or on irrigated land, pastures, forests and woodlands resulting from a combination of adverse factors, including specific practices of land use and land management". [1]

Today, more than two-thirds of Ukraine's agricultural lands are affected to one degree or another by military actions, primarily the most productive lands of the south and southeast of Ukraine [9, 10, 13].

Tools such as geoportals and dashboards, which allow you to visually display both specific cases and general trends, are widely used in the assessment of such

consequences. This approach makes it possible to carry out a comprehensive assessment of changes in land use and soil condition and to identify, on the one hand, the direction of the studied processes (deterioration / improvement of the condition), and on the other hand, to visualize spatial and temporal changes cartographically with the help of geoportals. We also note that it is possible to conveniently monitor synthetic and complex mapped indicators in dynamics, using electronic map tools to display several thematic layers in time dynamics (timeline). In the classification of soil degradation given in the work of Yu. Zaitsev. et al. [5], 11 of its types are distinguished (mechanical, physical, chemical, physico-chemical, biological, radiation, hydromelioration, waste pollution, destruction during construction, technologically dangerous processes and "low productivity"). Here, in our opinion, there are a number of shortcomings, namely, it does not take into account the specifics of soil disturbance as a result of military actions, and it is better suited for civilian peacetime conditions for assessing the damage caused to the soil. Also, this classification is given not by factors of impact, but by factors of degradation, thus, the impact on soils as a result of military actions will always be complex, and certain types will be manifested constantly (for example, mechanical), while others - in exceptional cases (for example, radiation or "low productivity"). The classification given in the work of the authors D. Dobryak, N. Kuzin has the same shortcomings. [4]. It should be noted that there are more successful classifications, adapted to use in the conditions of the impact of military actions on agricultural lands and soils, one of which we will consider further.

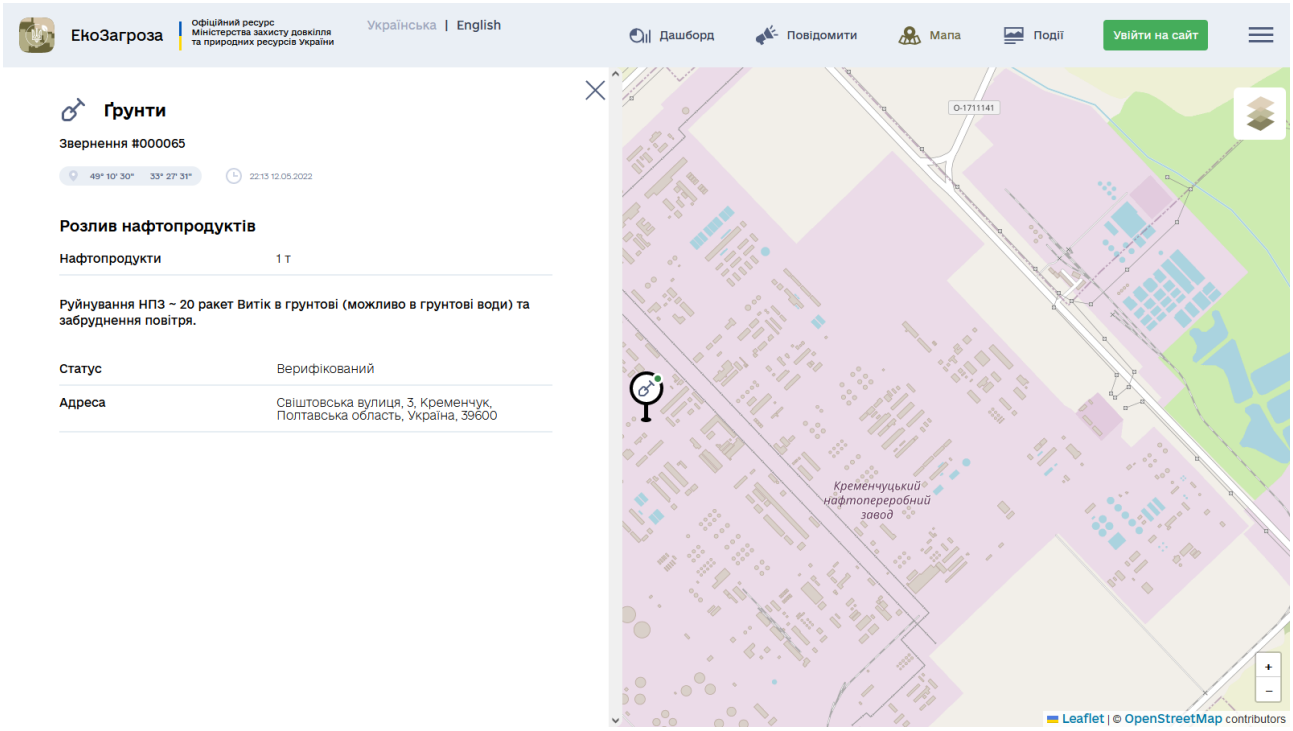

Fig. 1. An example of the impact of military actions on soils. Source: "Ekozagroza" Geoportal of the Ministry of Environmental Protection, 2023. [3]

In order to evaluate soil cover changes, it is necessary to have such soil cover maps that reflect the state of the studied area in the initial and final (target) period. Such maps must be of sufficient accuracy to enable comparisons to be made with an acceptable level of confidence. Quantitative methods for assessing the reliability of such maps have been developed over the past decades (Wessels K.J. [24]).

Figure 1 shows an example of the impact of military actions on the soil: as a result of enemy rockets hitting the territory of the refinery, its facilities were damaged, which led to the contamination of the soil cover of the adjacent territories with oil products and bringing the lands to a state that does not allow them to be used, in particular, in agricultural production.

Figure 2 shows a fragment of the map from the Ecodozor geoportal, where the impact of military actions on the disturbance of the soil cover and the detection of environmental risks for the soil are reflected using integral indicators. This approach is attractive for its clarity and informativeness, at the same time, it requires a careful selection of indicators capable of characterizing the entire range of possible impacts of military actions on the soil.

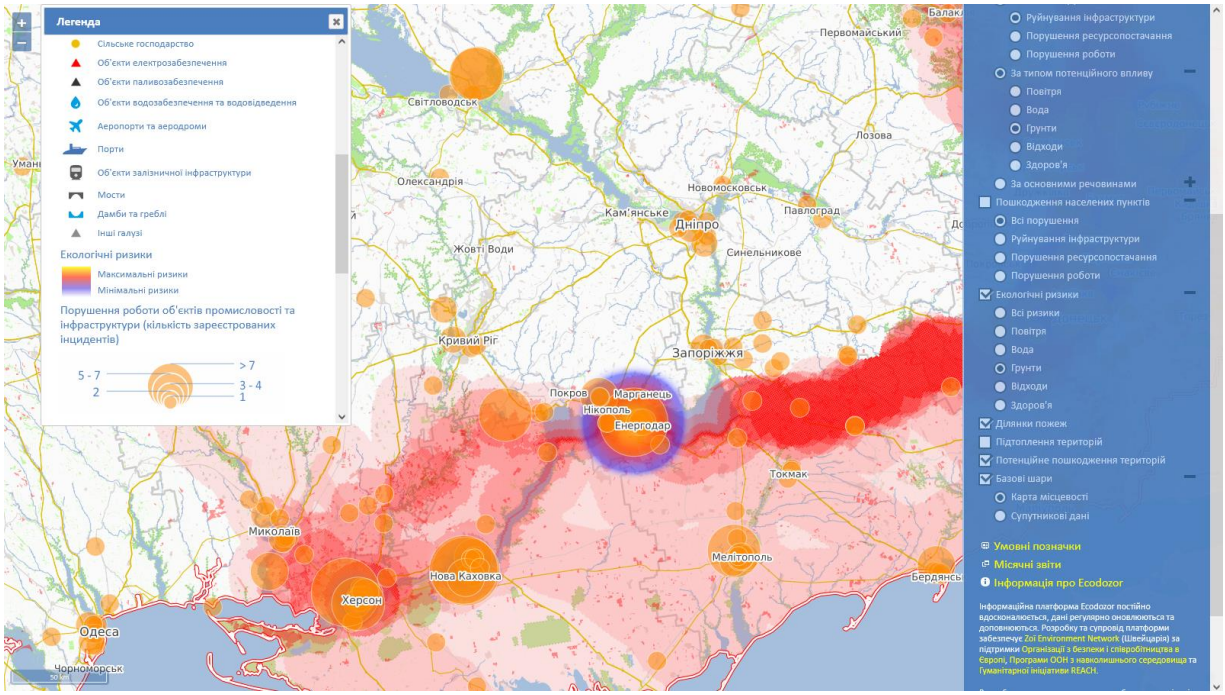

Fig. 2. The impact of military actions on the disturbance of the soil cover and the detection of ecological risks for the soil (fragment of the map, according to the data of the ecodozor.org service, 2023) [17]

The dashboard with data on environmental threats ecozagroza.gov.ua (EkoZagroza, 2022-2023) [3] contains a large array of background statistical information on the impact of military operations on natural resources, including soil cover. Such a means of presenting information is characterized by clarity, the space of perception of indicators, the ability to express complex concepts with the help of integral index indicators and their scales.

The main negative factors that lead to damage to agricultural land include (according to [7]):

"1. Driving through the territory of heavy equipment (tanks and other types of tracked equipment, which leads to soil compaction and degradation).

2. The use of anti-tank and anti-personnel mines, which leads to changes in landscapes, relief and soil degradation.

3. Shelling and bombing of the territory, which leads to the formation of craters (funnels) and mixing of soil horizons. Sinkholes in places where shells fall are not only a factor of landscape damage and destruction of vegetation, but also a factor of

soil pollution: they leave in the soil a significant amount of metal, sulfur and sulfur compounds, heavy metals, ammonia, phosphorus, coal dust, sulfuric acid and sulfate compounds, formaldehydes , lead, mercury.

4. Construction of trenches and other protective shelters for military personnel and equipment (soil disturbance and degradation).

5. Fires in natural areas and agricultural fields. As a result, the fertile soil layer burns out, dehydration and "sterilization" occurs - both pathogenic microorganisms and useful biota die, nutrients are lost."

In our opinion, this classification generally covers well the spectrum of factors affecting the soil cover of military operations. At the same time, this classification is incomplete and does not cover some common cases, for example, the creation of systems of defensive structures leads to the disturbance of soil horizons and changes in the soil structure, the spread of erosion (Makarenko N. A., etc. [19]). Also, since it was developed for the conditions of military operations in Donetsk region in the ATO zone as of 2014-2017, it needs to be supplemented and clarified, for example, it is worth adding the concepts of ecocide and violation of infrastructure. Also, according to the authors [2, 16], one of the most effective measures to restore lands damaged by explosions is natural restoration and planting of trees to prevent erosion.

Conclusions. As a result of the full-scale invasion in 2022, most of Ukraine's highly productive agricultural lands were temporarily unsuitable for agricultural production. Common classifications both by factors of influence and by groups of soil cover indicators, which have deteriorated as a result of military actions, need to be supplemented and clarified, for example, in our opinion, the concepts of ecocide and infrastructure violations should be added, in particular in relation to agricultural production.

The use of indicator indicators of the condition of lands and soils, as well as operational monitoring of the development of degradation processes based on remote sensing data and the possibility of using geoportals, dashboards and other means of public access to open data plays a particularly important role in the context of assessing the impact of the consequences of military actions on the soil cover, the

possibility of recovery agricultural production in such territories and the quality of life of people in general.

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ВПЛИВ ВІЙСЬКОВИХ ДІЙ НА ДИНАМІКУ ВИКОРИСТАННЯ СІЛЬСЬКОГОСПОДАРСЬКИХ ЗЕМЕЛЬ ТА СТАН ГРУНТОВОГО ПОКРИВУ

Актуальність теми зумовлена значними змінами стану компонентів навколишнього середовища, а саме ґрунтового покриву, використання сільськогосподарських угідь під впливом наслідків бойових дій у 2022-2023 роках. Виникає необхідність оцінки масштабів змін навколишнього середовища, насамперед ґрунтового покриву, як найбільш порушеного внаслідок бойових дій, під впливом цих факторів, визначення їх відповідних масштабів, просторової локалізації та еколого-правових наслідків. До основних негативних факторів,

що призводять до пошкодження сільськогосподарських угідь, належать (за Кондратенко А.Ф. 2022): 1. Проїзд територією великовагової техніки (цистерн та іншої гусеничної техніки, що призводить до ущільнення та деградації ґрунту); 2. Застосування протитанкових і протипіхотних мін, що призводить до зміни ландшафтів, рельєфу та деградації ґрунтів; 3. Обстріл і бомбардування території, що призводить до утворення воронок (воронок) і перемішування ґрунтових горизонтів. Воронки в місцях падіння снарядів є не тільки чинником пошкодження ландшафту та знищення рослинності, але й чинником забруднення ґрунту: вони залишають у ґрунті значну кількість металу, сірки та сірчистих сполук, важких металів, аміаку, фосфору, вугільний пил, сірчана кислота і сульфатні сполуки, формальдегіди, свинець, ртуть; 4. Будівництво окопів та інших захисних укриттів для військовослужбовців і техніки (порушення та деградація ґрунту); 5. Пожежі на природних територіях і сільськогосподарських полях. В результаті вигорає родючий шар грунту, відбувається зневоднення і «стерилізація» - гинуть як патогенні мікроорганізми, так і корисна біота, втрачаються поживні речовини. На нашу думку, ця класифікація в цілому добре охоплює спектр факторів, що впливають на ґрунтовий покрив військових дій. У той же час ця класифікація є неповною і не охоплює деякі типові випадки, наприклад, створення систем оборонних споруд призводить до порушення ґрунтових горизонтів і зміни структури ґрунту, поширення ерозії (Макаренко Н. А. та ін., 2022). Також, оскільки він розроблений для умов бойових дій у Донецькій області станом на 2014-2017 роки, потребує доповнення та уточнення, наприклад, варто додати поняття екоцид та руйнування інфраструктури. Особливо важливу роль у контексті впливу наслідків відіграє використання індикаторів стану ґрунтів, моніторинг розвитку деградаційних процесів на основі оперативних даних та можливість використання геопорталів, дашбордів та інших засобів публічного доступу до відкритих даних. воєнних дій на ґрунтовий покрив, перспективи сільськогосподарського виробництва та, загалом, на якість життя.

Ключові слова: *сільськогосподарські угіддя, ґрунтовий покрив, деградація ґрунтів, динаміка землекористування, військові дії.*