








## DETERMINATION OF ECONOMIC LOSSES ON AGRICULTURAL LAND IN CONNECTION WITH HOSTILITIES ON THE EXAMPLE OF THE TERRITORY OF KYIVSKA OBLAST IN UKRAINE

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### ABSTRACT

#### Aim of the study

The aim of the study is a determination of economic losses on agricultural land (arable land) that have been affected by hostilities and need further measures to demine them and to make them suitable for safe food production in order to resolve the acute humanitarian and food crisis.

#### Material and methods

The generally accepted methods of scientific research are used: monographic, statistical, analytical, method of comparison, method of interpolation, forecasting, abstract-logical and engraving.

#### Results and conclusions

Economic losses caused by hostilities on the example of the agricultural land (arable land) in Kyivska oblast in Ukraine were calculated. The spatial aspect of administrative-territorial reform carried out in Ukraine in terms of changes to the number of administrative districts and their area was considered. This reform was done in order to be able to work with the data on agricultural land collected for both new and old administrative-territorial divisions of Kyivska oblast. The approximate duration of demining works on territories affected by hostilities was considered, taking into account various degrees of shelling intensity and demining works complexity. The unearned income of agricultural producers within cereals, legumes and oilseeds in Kyivska oblast were calculated. The calculations of economic losses associated with the cost of demining works and the impossibility of growing crops in Kyivska oblast were made. Results obtained for Kyivska oblast were interpolated in order to determine the approximate area of arable land affected by hostilities and therefore economic losses on this land throughout Ukraine.

**Keywords:** crop production, demining, humanitarian and food crisis, land contamination, sown area.

## INTRODUCTION

The full-scale hostilities that have engulfed Ukraine since February 24, 2022 have aggravated the world humanitarian and food crisis and exacerbated the economic, environmental and social problems of humanity (e.g., Fang and Shao, 2022). In addition to the war, which is the greatest threat to humanity, the food crisis and the negative impact of hostilities on the environment are equally important (e.g., Pereira et al., 2022a; Arora and Sarker, 2023; Racioppi et al., 2022; Ben Hassen and El Bilali, 2022).

The escalation of the Russian-Ukrainian armed conflict poses a serious threat to the achievement of the United Nations Sustainable Development Goals, not only for the countries directly involved in the conflict, but also for other countries, especially in developing regions that are more vulnerable to the economic crisis (Pereira et al., 2022b). The armed conflict in Ukraine could reinforce inflationary effects, pushing up the prices of food and other commodities around the world, due to rising energy prices and the potential loss of grain supplies from both Ukraine and Russia (Tollefson, 2022). Prohorovs (2022) found that Russia's War in Ukraine will have a long-term, large-scale negative impact on most European companies and economies.

Armed conflicts disrupt the environment and impair land productivity (Zhang et al., 2023). Given Ukraine's significant role in the food segment of Europe and the world, it is imperative to assess the consequences of hostilities in the agricultural sector and their impact on the environment. The production of agricultural products is the basis of national security, providing food to domestic consumers, the people of Ukraine, and foreign consumers through exports, which together allow to fill the country's GDP and reduce the share of world hunger (FAO, 2022; USDA, 2022).

The soil cover of agricultural land is negatively affected by the movement of heavy equipment, construction of various fortifications, shelling, contamination by the remains of destroyed military equipment and explosives. The destruction of soil cover as a result of future hostilities can accelerate various types of degradation processes in these areas, reduce fertility and pollute groundwater, forcing changes in land use.

However, the most dangerous are unexploded ordnance and minefields remaining after hostilities, due to which no use of these lands is safe (e.g., Pereira et al., 2022a; Pereira et al., 2022b; Kucher, 2022). Yin et al. (2019) found that conflict intensity was positively correlated with the abandonment of agricultural land, but the effects differed based on the distance to conflicts and the intensity measure.

According to the Land Code of Ukraine, land that is polluted as a result of human economic activity, which has led to land degradation and its negative impact on the environment and human health, is designated by the term "technogenic pollution of land", and immediate measures for its restoration must be taken. (Verkhovna Rada of Ukraine, 2001).

Thus, the main issues currently facing Ukraine in order to ensure food security and reduce risks in agriculture are the identification of arable land that cannot be used for agricultural production due to the war, the maximum restoration of such land for its safe use according to its intended purpose under the Ukrainian land law, the production of ecologically clean products, including for domestic consumption, the protection of population and the creation of favorable conditions for business. Destruction of housing and critical urban infrastructure due to hostilities will also lead to forced population displacement. It is predicted that some Ukrainians will leave the country, while others will temporarily settle in rural areas, where there is less dependence on critical infrastructure (Department of Economics of NAS of Ukraine, 2022). Some key components of such migration from urban to rural areas are stable development of agricultural production, improvement of working and living conditions of the population, and preservation of the natural environment.

Gibson et al. (2015) examined the assessment of arable land and agricultural products grown in Iraq before, during and after military action. They considered UN data and obtained remote sensing data to monitor changes in land cover and the structure of agriculture in Iraq (Gibson et al. 2015). Scientists in the field of environmental research (e.g., Eklund et al., 2017) analysed different conflicts and their dependence on changes in the land system on the example of hostilities in Syria and Iraq. The researchers used time series approaches based on remote sens-

ing data to estimate cultivated areas in the period of 2000–2015 (Eklund et al., 2017). Similar studies have been conducted with the support of the Food and Agriculture Organization of the United Nations (FAO), which have identified different types of damage in the areas where the fighting took place. The work of Ukrainian land managers, surveyors, economists, and ecologists is also devoted to this issue: in Ukraine, there is an objective need to develop experimental land management projects that will take into account the specific features of territories affected by hostilities, which caused destruction and pollution (NULES, 2018). Similar studies have already been made on the example of the territories of the Donetsk and Luhanska oblasts, which have been affected by active hostilities in the period from 2014 to 2015 (Vasyliuk and Norenko, 2016).

Libanova et al. (2015) highlighted that as a result of hostilities in the Donetsk and Luhanska oblasts, a large part of the land was under the control of illegal armed formations. This situation meant the removal of large areas of agricultural land from food production. A serious problem is the destruction of arable land, which cannot be processed normally after shelling. Another problem is the degradation or destruction of forest protection strips, which are important for agriculture.

Special mention should be made of the research of some scientists who have studied changes in agriculture and the structure of land use on territories, which have suffered hostilities throughout the country or a significant part of it. Belenok et al. (2022) propose a combination of several methods for the analysis and assessment of anthropogenically transformed landscapes of the city of Bila Tserkva (Ukraine) using Earth remote sensing data for 1985–2020 and GIS mapping of the changes. They proved that remote sensing from space is the most efficient existing modern method of obtaining information, because the information retrieved in this way allows not only to continuously monitor urban areas and control potentially dangerous areas, but also to create databases of space images from different time periods, which are the basis for statistical research, modeling, assessment and forecasting of the condition of urban areas. Also Belenok et al. (2021) considered the change in natural landscapes and their current state, taking into account

the spatio-temporal changes of water bodies, vegetation, urban areas, and bare soil with the help of remote sensing data processing on the example of the capital of Ukraine – Kyiv. On the basis of such a study, it will be possible to determine more precisely with remote sensing data, which areas were affected by hostilities in Ukraine.

Hebryn-Baidy et al. (2021) developed prospects for the development of eco-innovative agricultural production of niche cultures for the restoration of soil fertility in Ukraine. The authors emphasized that inadequate provision of organizational and technological approaches to the use and management of unproductive, degraded, sloping land had a negative impact on the stability of agricultural landscapes in Ukraine. As a result, soils are losing a significant share of humus and the reduction of their productivity is continuing (Hebryn-Baidy et al. 2021).

The scientists achieve similar results with different research methods for different territories. However, their research objects still have their own specifics related to both culture and natural conditions of Syria and Iraq (Gibson et al., 2015; Eklund et al., 2017). In Ukraine the natural environment and the legislative framework differ from Asian countries, requiring the search for new methods of estimating economic losses on agricultural land caused by hostilities.

Therefore, the aim of the study is to determine the economic losses. According to the (UNDDR, 2023) there are a direct and indirect economic losses. Under economic losses we mainly consider indirect losses because direct ones occur at the time of the event, i.e. when the field is targeted by the warfare and the crops grown on it are destroyed. Direct losses are not considered in this study, because their assessment or even estimation is impossible. Thus, the subject of our study is the assessment of indirect losses, which are first of all the costs of demining works and unearned income due to the physical danger caused by mines and other explosive substances and the degradation of fields due to soil pollution, which leads to incompatibility of the qualitative composition of the soil with the state norms. Results obtained for Kyivska oblast can be interpolated in order to determine the approximate area of arable land affected by hostilities and therefore the economic losses on these lands throughout Ukraine.

## MATERIALS AND METHODS

To determine the economic losses of agricultural land, the arable land areas within the territory of the Kyivska oblast in Ukraine, where the fighting took place, were selected. The generally accepted methods of scientific research are used in the following study are: monographic, statistical, analytical, comparison, interpolation, forecasting, abstract-logical and engraving.

The monographic method was used to analyze the works of scientists who have studied the issue of the losses of agricultural land during hostilities, its structural changes, crops grown, purpose and measures to restore its productivity. The obtained results in the studied time period (to find out if demining is needed) using the monographic method were compared with studies of other scientists, as well as similar work carried out by the Center for Humanitarian Demining of the state enterprise “Ukroboronservis” in previous years in Ukraine-controlled parts of Donetsk and Luhanska oblasts.

Statistical and analytical methods were used in the process of collecting the initial data for the study. They allowed to systematize the original data and other information and to convert it into a single quantity system:

- arable land area according to the state statistical reports on the quantitative accounting of land (No. 6-zem form) in hectares;
- actual sown area of arable land according to the statistical bulletin No. 29 “Areas, gross harvests and yields of crops, fruits, berries and grapes in farms of Kyivska oblast in 2020” in hectares, which requires inspection;
- the average area of the territory surveyed in the Kyivska oblast per day in hectares;
- the production of cereals, legumes and oilseeds in tons;
- the selling price of agricultural products in US dollars;
- the price of the surveying and demining of agricultural land in US dollars.

The same data can be collected for other oblasts in Ukraine affected by hostilities, in order to calculate the costs of demining works.

Using a combination of comparison and interpolation, the transition from the administrative dis-

tricts that existed before the administrative reform in Ukraine until 2020 to the administrative districts formed in 2020 was made. It was necessary in order to apply both the data collected for the old and the new administrative districts, for example, the initial data of the statistical reports on arable land, actual sown areas, production of grain, legumes and oilseeds in the administrative districts of Kyivska oblast.

The methods of analysis and interpolation were used to evaluate the approximate areas of agricultural land survey by analyzing information from official data of the State Emergency Service of Ukraine on the results of survey, detection, removal, and destruction of explosive devices action.

The interpolation method was also used to determine the unearned revenue on arable land that was affected by hostilities throughout Ukraine based on the results obtained for Kyivska oblast. We have also considered the forecast of the National Bank of Ukraine that the inflation rate will be increasing by the end of 2022.

The forecasting method was used in order to assess the unearned revenue of agricultural producers in Kyivska oblast and subsequently throughout Ukraine, taking into account the impossibility of using sown areas for a significant period of time, the aggravation of the humanitarian crisis, and the disruption of logistics and production processes.

Summarizing the results, an abstract-logical method was used to draw conclusions about the identified economic losses on agricultural land caused by hostilities, as well as suggestions for further research on areas of agricultural land that are in need of survey and subsequent demining, and as a consequence, the use and implementation of conservation measures in technologically contaminated areas.

To determine the economic losses on agricultural land in the study area, we calculated the data in the following sequence:

- the arable land and sown area in need of survey/demining was calculated using the arable land and sown area according to the statistics and percentage of the area that require survey/demining (Table 1);
- to determine the approximate number of days for surveying/demining of arable land we divided the arable land area and the sown area of arable land

in need of survey/demining into the average value of survey/demining area per day in Kyivska oblast (Table 1);

- the cost of survey work and the cost of demining of arable land was calculated using the arable land area and sown area of arable land in need of survey/demining and the cost of both survey and demining per hectare (Table 3);
- to determine the number of agricultural crops in tons that won't be produced in dangerous or ineligible areas we used the production of cereals, legumes and oilseeds and the percentage of the area in need of survey/demining (Table 4);
- the unearned income of agricultural producers in 2022 on the territory of Kyivska oblast was calculated by multiplying the number of agricultural crops in tons that won't be produced in dangerous or ineligible areas by the average selling price of cereals, legumes and oilseeds (Table 5).

An engraving was used to show the location and areas, where were the occupation or hostilities took place and where the research was conducted (see: Figure 1). Kyivska oblast was selected as the case study area for this calculation. This region is one of the three regions that experienced active hostilities in the period from February 24, 2022 to April 2, 2022 and was liberated from the occupiers in its entirety on April 5, 2022.

Work on the identification of dangerous areas which may be mined or in which hostilities took place, was conducted the basis of information provided by the State Emergency Service of Ukraine (hereinafter – SESU).

## RESULTS AND DISCUSSIONS

The administrative districts of Kyivska oblast with an area of approximately 796,735.00 ha, in particular Buchansky (91%), Vyshgorodsky (80%), Brovarsky (15%) and partially Fastivsky (3%), fell into the zone of possible mining. Given that the share of agricultural land is dominant in the structure of the land, it will be the most “contaminated” due to hostilities and possible mining.

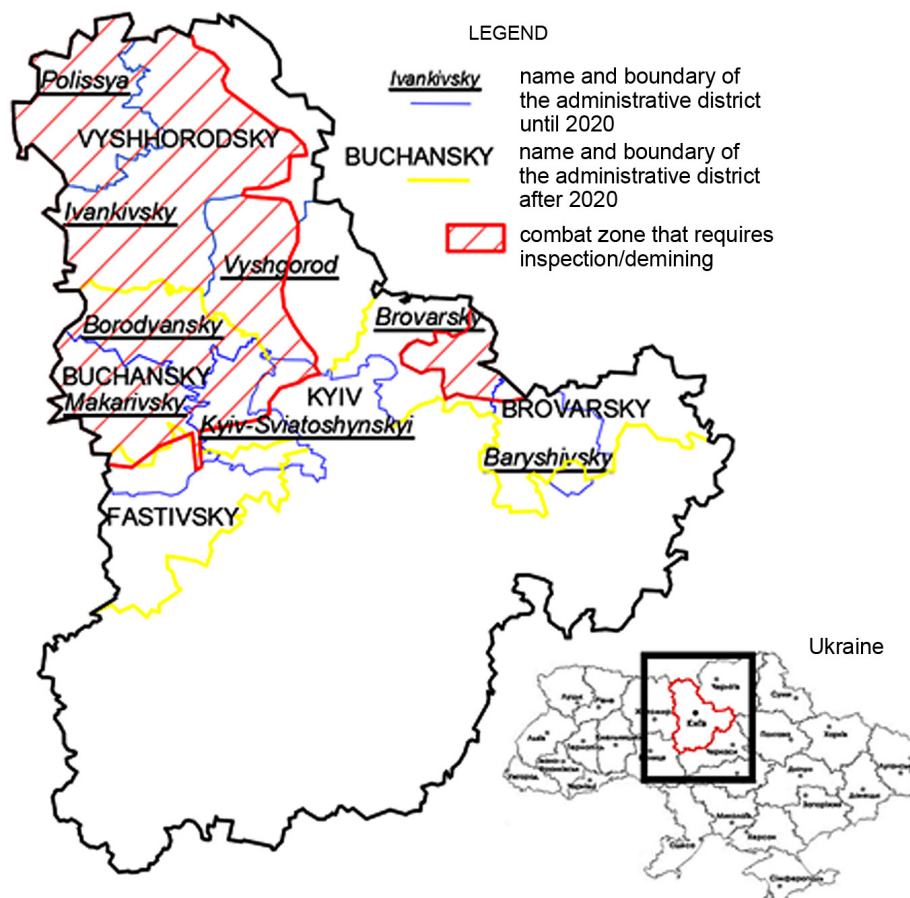
As the administrative reform took place in 2020, the statistical reporting has not yet been fully transferred to the new administrative districts. Therefore, in order to ensure the objectivity of the calculation of

a possible algorithm for determining the area of arable land and the actual sown areas that need to be surveyed/demined, the boundaries of administrative districts until 2020 were adopted. The use of the boundaries of administrative districts that existed before the 2020 administrative reform allows the use of existing statistical information on these areas. Thus, the following administrative districts that functioned in Kyivska oblast until 2020 were included in the survey/demining zone: Baryshivsky, Brovarsky, Borodyansky, Vyshgorodsky, Kyiv-Sviatoshynsky, Makarivsky, Ivankivsky, Polissky (see: Figure 1).

According to the state statistical reporting on the quantitative accounting of land (No. 6-zem form) as of 01.01.2016, the total area of arable land in the above-mentioned districts was 337,321.6677 hectares. It should be noted that some parts of these districts remained free from hostilities, therefore there is no need to conduct demining surveys on the entirety of their territories.

Taking into account the information materials of the SESU, the possible share of arable land that needs to be surveyed was calculated. As Borodyanskyi, Ivankivskyi and Polisskyi districts were fully occupied from March 24, 2022 to April 4, 2022, their entire area has to be surveyed and demined. The fighting covered the territory of Makarivskyi district (77%), Kyiv-Sviatoshynskyi district (50%), Vyshgorodskyi district (49%), Brovarskyi district (35%), Baryshivskyi district (4%). According to the specified areas of hostilities, we can adjust the possible area of arable land that requires survey and demining. Thus, the total area of arable land in the above-mentioned areas is 201,327.00 ha.

The actual area of arable land that was intended for crops was also taken into account. According to the statistical bulletin No. 29 “Areas, gross harvests and yields of crops, fruits, berries and grapes in farms of Kyivska oblast in 2020” arable land area sown with crops was 188,600.00 hectares. Considering the areas of hostilities, the endangered sown area was 105,752.00 hectares. According to the information from the official portal of the SESU on demining, the average surveyed/demined area within the Kyivska oblast was 273.00 hectares per day (surveyed areas per day in ha from 07/04/22 to 16/04/22) (see: Tables 1) (SESU, 2022).



**Fig. 1.** Part of the territory of Kyivska oblast in Ukraine within the administrative districts, which requires survey and demining on agricultural land (arable land)

Thus, it took 2 to 3 months to survey the territory of Kyivska oblast according to the old administrative zoning of Baryshivsky, Brovarsky, Borodyansky, Vyshgorodsky, Kyiv-Sviatoshynskiy, Makarivsky, Ivankivsky, Polissya districts.

However, the experience of demining similar areas shows, that it may take much longer, depending on the amount of unexploded ordnance or its rests. In 2021 deminers surveyed and demined a total area of 2,723 hectares in the territory of Donetsk and Luhansk oblasts controlled by Ukraine. If we calculate an area per day, we get 7 hectares, which is incomparable with the figure we obtained on the basis of SESU data, 273 hectares per day in Kyivska oblast in 2022 (SESU, 2022).

In the paper “Donbas loses fertile lands due to mined fields” Yuriy Kolesnyk, head of the Center

for Humanitarian Demining of the state enterprise “Ukroboronservice”, adds that duration depends purely on the organization of work. If everything is done correctly, then the demining of 5 hectares can take only 2–3 months. But first, these areas have to be surveyed. Taking into account the number of mines, the cost of “X-ray” per square meter is about 10 cents, demining – 1 USD. The minefields in question were 20 cm deep, which is enough for plowing (SuperAgronom, 2018).

If we consider, that it takes 3 months to survey and demine 5 hectares of arable land, we can interpolate it proportionally and arrive at a result of 18 days per hectare. Therefore, we calculated the time needed for the survey/demining in Kyivska oblast (see: Table 2).

**Table 1.** Determination of arable land area and calculation of the number of days needed for survey/demining of arable land in Kyivska oblast of Ukraine

No.	Name of the district	Arable land area according to the form No. 6-zem of state statistical reporting on land resources on 01.01.2016, ha	The sown area according to the statistical bulletin No. 29 in 2020, ha	Percentage of area requiring survey/demining, %	The area of arable land requiring survey/demining, ha	The sown area requiring survey/demining, ha	The average surveyed/demined area within the Kyivska oblast, ha per day	Approximate number of days needed for survey/demining of arable land	
		(1)	(2)	(3)	1*3 (4)	2*3 (5)	(6)	4/6 (7)	5/6 (8)
1	Baryshivsky	58,483.3275	51,546.00	4	<b>2,339.00</b>	<b>2,062.00</b>	273	<b>9</b>	<b>8</b>
2	Brovarsky	57,697.1050	29,201.00	35	<b>20,193.00</b>	<b>10,220.00</b>		<b>74</b>	<b>37</b>
3	Borodyansky	28,367.5931	13,547.00	100	<b>28,367.00</b>	<b>13,547.00</b>		<b>104</b>	<b>50</b>
4	Vyshgorod	25,626.4732	4,658.35	49	<b>12,556.00</b>	<b>2,282.00</b>		<b>46</b>	<b>8</b>
5	Kyiv-Sviatoshynskyi	29,458.7325	8,037.72	50	<b>14,729.00</b>	<b>4,019.00</b>		<b>54</b>	<b>15</b>
6	Makarivsky	63,235.3200	34,726.07	77	<b>48,691.00</b>	<b>26,739.00</b>		<b>178</b>	<b>98</b>
7	Ivankivsky	52,137.2464	32,866.96	100	<b>52,137.00</b>	<b>32,867.00</b>		<b>191</b>	<b>120</b>
8	Polissya	22,315.8700	14,016.90	100	<b>22,315.00</b>	<b>14,016.00</b>		<b>82</b>	<b>51</b>
TOTAL		337,321.6677	188,600.00		<b>201,327.00</b>	<b>105,752.00</b>			
AVERAGE				64				<b>92</b>	<b>48</b>

**Table 2.** Determination of arable land area and time needed for the survey/demining in Kyivska oblast, Ukraine

No.	Name of the district	Arable land area according to the form No. 6-zem of state statistical reporting on land resources on 01.01.2016, ha	The sown area according to the statistical bulletin No. 29 in 2020, ha	Percentage of area requiring survey/demining, %	The area of arable land requiring survey/demining, ha	The sown area requiring survey/demining, ha	Number of days required for survey/demining of 1 ha	Approximate number of days needed for survey/demining of arable land	
		(1)	(2)	(3)	1*3 (4)	2*3 (5)	(6)	4/6 (7)	5/6 (8)
1	Baryshivsky	58,483.3275	51,546.00	4	2,339.00	2,062.00	18	<b>130</b>	<b>115</b>
2	Brovarsky	57,697.1050	29,201.00	35	20,193.00	10,220.00		<b>1122</b>	<b>568</b>
3	Borodyansky	28,367.5931	13,547.00	100	28,367.00	13,547.00		<b>1576</b>	<b>753</b>
4	Vyshgorod	25,626.4732	4,658.35	49	12,556.00	2,282.00		<b>698</b>	<b>127</b>
5	Kyiv-Sviatoshynskyi	29,458.7325	8,037.72	50	14,729.00	4,019.00		<b>818</b>	<b>223</b>
6	Makarivsky	63,235.3200	34,726.07	77	48,691.00	26,739.00		<b>2705</b>	<b>1486</b>
7	Ivankivsky	52,137.2464	32,866.96	100	52,137.00	32,867.00		<b>2897</b>	<b>1826</b>
8	Polissya	22,315.8700	14,016.90	100	22,315.00	14,016.00		<b>1240</b>	<b>779</b>
TOTAL		337,321.6677	188,600.00		201,327.00	105,752.00			
AVERAGE				64				<b>1398</b>	<b>734</b>

If we convert the number of days into months and years, we get 4 years of survey/demining works necessary for the arable land areas according to the form No. 6-zem of state statistical reporting on land resources on 01.01.2016, or 2 years for actually sown areas according to the statistical bulletin No. 29 in 2020. This is definitely a long period.

We can calculate the estimated cost of these works separately, adopting the thesis of the head of the Center for Humanitarian Demining of the state enterprise “Ukroboronservice”. Taking into account the volume of mines, the cost of survey per square meter is about 10 cents, demining – about 1 USD. So, survey of 1 hectare area costs 100,000.00 cents, or 1,000 USD. If necessary, 1 hectare of demining works costs about 10,000 USD (see: Table 3). Thus, the survey and demining works of the arable land may cost one billion one hundred sixty-three million two hundred seventy-two thousand USD (1,163,272,000.00 USD).

Other economic losses for these areas are an unearned income due to the impossibility of cultivating agricultural products before and during the survey/demining.

According to the data from the statistical bulletin No. 29 “Agricultural land, gross harvest and yield of crops, fruits, berries and grapes in the farms of Kyivska oblast in 2020”, the most common crops are cereals, legumes and oilseeds. Their share in the total sown area of arable land is over 90%.

Using the data from the bulletin No. 29 on the production of cereals, legumes and oilseeds, as well as the share of the area that needs to be surveyed/demined, we can calculate the approximate areas of possible agricultural products, that could be grown in these areas (see: Table 4). According to the published report on the prices of cereals, legumes and oilseeds in Ukraine on February 14, 2022 in the ports of Odesa and Mykolaiv oblasts, the average price of grain was 275.00 USD and of oil – 636.00 USD (SuperAgronom 2022). Based on the data of possible agricultural products, that could be grown in the relevant areas and the selling price, we calculated the unearned income of land users in the amount of 133,147,881.00 USD (see: Table 5).

According to the State Statistics Service of Ukraine, the share of Kyivska oblast in the production of all agricultural products in 2021 was 5.7%. However, ac-

**Table 3.** Price of survey/demining works on arable land in Kyivska oblast, Ukraine

No.	Name of the district	The sown area requiring survey/demining, ha	The cost of the survey per hectare, USD	The cost of demining per hectare, USD	The cost of the survey of arable land, USD	The cost of demining of arable land, USD	Total costs, USD
		(1)	(2)	(3)	1*2 (4)	1*3 (5)	4+5 (6)
1	Baryshivsky	2,062.00			2,062,000	20,620,000	<b>22,682,000.00</b>
2	Brovarsky	10,220.00			10,220,000	102,200,000	<b>112,420,000.00</b>
3	Borodyansky	13,547.00			13,547,000	135,470,000	<b>149,017,000.00</b>
4	Vyshgorod	2,282.00			2,282,000	22,820,000	<b>25,102,000.00</b>
5	Kyiv-Sviatoshynskyi	4,019.00	1,000.00	10,000.00	4,019,000	40,190,000	<b>44,209,000.00</b>
6	Makarivsky	26,739.00			26,739,000	267,390,000	<b>294,129,000.00</b>
7	Ivankivsky	32,867.00			32,867,000	328,670,000	<b>361,537,000.00</b>
8	Polissya	14,016.00			14,016,000	140,160,000	<b>154,176,000.00</b>
	<b>TOTAL</b>	105,752.00			13,219,000	132,190,000	<b>1,163,272,000.00</b>



**Table 4.** Calculation of possible agricultural production in areas requiring survey/ demining in the Kyivska oblast, Ukraine

No.	Name of the district	Production of cereals and legumes, ton	Production of oilseeds, ton	Percentage of area requiring survey/ demining, %	Possible production of cereals and legumes, ton	Possible production of oilseeds, ton
		(1)	(2)	(3)	1*3 (4)	2*3 (5)
1	Baryshivsky	186,101.00	40,188.00	4	<b>7,444.00</b>	<b>1,608.00</b>
2	Brovarsky	99,671.00	26,621.00	35	<b>34,885.00</b>	<b>9,317.00</b>
3	Borodyansky	22,400.00	9,845.00	100	<b>22,400.00</b>	<b>9,845.00</b>
4	Vyshgorod	4,107.00	4,411.00	49	<b>2,013.00</b>	<b>2,162.00</b>
5	Kyiv-Sviatoshynskiyi	12,251.00	8,787.00	50	<b>6,125.00</b>	<b>4,394.00</b>
6	Makarivsky	134,798.00	25,947.00	77	<b>103,795.00</b>	<b>19,980.00</b>
7	Ivankivsky	65,239.00	30,719.00	100	<b>65,239.00</b>	<b>30,719.00</b>
8	Polissya	48,418.00	5,796.00	100	<b>48,418.00</b>	<b>5,796.00</b>
TOTAL		572,985.00	1,523,134.00		<b>290,319.00</b>	<b>83,821.00</b>

**Table 5.** Calculation of the unearned income on the lands requiring survey/demining in 2022 in the Kyivska oblast, Ukraine

No.	Name of the district	Possible production of cereals and legumes, ton	Possible production of oilseeds, ton	The average selling price per 1 ton, USD		Unearned income from possible cereals and legumes production, USD	Unearned income from possible oilseeds production, USD
		(1)	(2)	cereals and legumes (3)	oilseeds (4)	1*3 (5)	2*4 (6)
1	Baryshivsky	7,444.00	1,608.00	275.00	636.00	2,047,100.00	1,022,688.00
2	Brovarsky	34,885.00	9,317.00			9,593,375.00	5,925,612.00
3	Borodyansky	22,400.00	9,845.00			6,160,000.00	6,261,420.00
4	Vyshgorod	2,013.00	2,162.00			553,575.00	1,375,032.00
5	Kyiv-Sviatoshynskiyi	6,125.00	4,394.00			1,684,375.00	2,794,584.00
6	Makarivsky	103,795.00	19,980.00			28,543,625.00	12,707,280.00
7	Ivankivsky	65,239.00	30,719.00			17,940,725.00	19,537,284.00
8	Polissya	48,418.00	5,796.00			13,314,950.00	3,686,256.00
TOTAL		290,319.00	83,821.00			<b>133,147,881.00</b>	

According to previous studies, a significant share of agricultural production falls on the central and southern regions of Kyivska oblast due to more fertile soils and favorable climatic conditions (Dorosh et al. 2018). In 2021 11% of the gross output of cereals and legumes, and 13% – of oilseeds were produced on the areas affected by hostilities and requiring survey/demining.

The humanitarian and food crisis should also be highlighted. Human resources that have been involved in the agricultural production process are no longer fully available. Many people were killed or forced to move to safer areas. In Ukraine more than 6 million people have become refugees, who have left the country, and at least 8 million people have been forced to flee their homes and relocate to other Ukrainian regions, with thousands more unable to leave the danger zones (UNHCR Ukraine 2022). Poverty in Ukraine is predicted to increase, but the situation in urban settlements will still remain better than in rural areas (Ptoukha Institute for Demography and Social Studies of NAS of Ukraine 2022).

Nearly 500,000 people lived in the areas affected by hostilities, which is up to 30% of the total population of Kyivska oblast. Both living and farming in these areas are potentially dangerous, which greatly exacerbates the humanitarian crisis in the region. Due to the lack of agricultural production on areas affected

by hostilities, and therefore the need to their survey and demine, the agricultural production will decrease by 40% in the Kyivska oblast, and its share will decrease to 3.4% by the end of 2022 from 5.7% in 2021 (Kupchenko 2022).

The calculated economic losses of agricultural production in Kyivska oblast in 2022 can be interpolated to the entire territory of Ukraine. Similarly, it is possible to identify the arable land that will not be used for sowing due to hostilities. We can thus assume that in Ukraine as a whole the proportion of arable land will drop from 30 to 34%. According to similar estimates by other scientists, the area of arable land is at least 11,005,300.00 hectares, which corresponds to more than 30% of the total arable land in Ukraine (UNCG 2022). Accordingly, the unearned income on these territories in monetary terms will be 13,856,308,861.00 USD. However, this is only a small part of the losses due to the inability to access the areas requiring survey and demining. According to a similar calculation and interpolation of the data within Ukraine, the survey and demining works on the sown area of arable land may cost 121,058,300,000.00 USD.

As a summary of the study with its calculations on the example of Kyivska oblast and the interpolations at the level of Ukraine, we present the main results in Table 6.

**Table 6.** The main results of the calculations in Kyivska oblast and Ukraine

No.		Kyivska oblast	Ukraine
1	Total area of arable land requiring survey and demining	201,327.00 he	36,538,900.00 he
2	The area of arable land located within the risk zone of agriculture	105,752.00 he	11,005,300.00 he
3	Estimated losses of agricultural products of cereals, legumes, oilseeds due to the impossibility of sowing and harvesting	374,140.00 ton	44,021,200.00 ton
4	Approximate duration of survey and demining of the arable land	from 2–3 months to 2–4 years	
5	The share of arable land located within the risk zone of agriculture	30–34%	
6	Estimated reduction in agricultural production by the end of 2022	40%	
7	Unearned income due to physical threat of mines and other explosive substances and the inaccessibility of fields due to the pollution of soils, and therefore the impossibility to harvest or sow the fields	133,147,881.00 USD	13,856,308,861.00 USD
8	Approximate price of survey and demining works on arable lands	1,163,272,000.00 USD	121,058,300,000.00 USD

## CONCLUSIONS

The time required to survey/demine the administrative districts of the Kyivska oblast, in particular Buchanskyi (91%) and Vyshhorodskyi (80%), may take years according to the calculations. Considering that areas of these districts were affected to a lesser extent, it may take months to survey/demine Brovarskyi (15%) and Fastivskyi (3%).

The discrepancy in the approximate duration of the survey/demining can only be explained by the fact that these works are quite complex, and the same area can be “cleared” at different rates, depending on the circumstances. The final stage, which allows a land user to use their land safely, is “humanitarian” demining. As the cost of such demining works is quite high, the budget has to be supplemented to a large extent by donor assistance, funds from the landowners, and the land users. We agree with the opinion of Department of Economics of NAS of Ukraine (2022), that in the future, the task of territorial development should be differentiated according to the degree of destruction of infrastructure, new placement of economic objects and resettlement, and in general – to harmonize the relations of economic actors and the compensation system in the field of natural and social environment management (Department of Economics of NAS of Ukraine 2022).

**Prospects.** All areas affected by hostilities remain potentially contaminated land, the use of which will require special measures. According to Ukrainian land law – technogenic pollution of agricultural land, which does not provide products that meet the established requirements (norms, rules, regulations), are subject to withdrawal from agricultural circulation and conservation (Verkhovna Rada of Ukraine, 2001). remote sensing data can be used to determine the actual area of agricultural land (arable land) requiring survey/demining works, as well as to determine the degree of its technogenic pollution. Determination of the actual area of agricultural land (arable land) that has become technogenically contaminated, is necessary for further implementation of land management measures, including conservation of these areas in order to restore them and return to agricultural use.

Other research perspectives also are:

- assessment of the loss of the productive potential of the lands of territorial communities affected by hostilities;

- justifying new approaches and a more objective assessment of the productive potential of lands affected by hostilities;
- developing a forecast and establishing a monitoring of the effectiveness of measures to restore the productive potential of the lands of territorial communities affected by hostilities.

## REFERENCES

- Arora, R.U., Sarker, T. (2023). Financing for sustainable development goals (SDGs) in the era of COVID-19 and beyond. *The European Journal of Development Research*, 35, 1–19. DOI: <https://doi.org/10.1057/s41287-022-00571-9>.
- Belenok, V., Hebryn-Baidy, L., Bielousova, N., Zavarika, H., Sakal, O., Kovalenko, A. (2022). Geoinformation mapping of anthropogenically transformed landscapes of Bila Tserkva (Ukraine). *Acta Sci. Pol. Formatio Circumiectus*, 21(1), 69–84. DOI: <https://doi.org/10.15576/ASPFC/2022.21.1.69>.
- Ben Hassen, T., El Bilali, H. (2022). Impacts of the Russia-Ukraine war on global food security: Towards more sustainable and resilient food systems? *Foods*, 11(15), 2301. DOI: <https://doi.org/10.3390/foods11152301>.
- Department of Economics of NAS of Ukraine (2022). Post-war revival of Ukraine: Vision Department of Economics of the NAS of Ukraine. Kyiv, Department of Economics of NAS of Ukraine. <https://files.nas.gov.ua/PublicMessages/Documents/0/2022/12/%D0%92%D1%96%D0%B7%D1%96%D1%8F%20-%202022.12.05.pdf>.
- Dorosh, O., Dorosh, I., Kupriyanchyk, I., Butenko, Y., Kharytonenko, R. (2018). Assessment of land resources productive potential influence on agricultural products gross output in Ukraine. *Scientific papers Series “Management, Economic Engineering in Agriculture and rural Development”*, 18.3, 107–114. [https://management-journal.usamv.ro/pdf/vol.18\\_3/Art14.pdf](https://management-journal.usamv.ro/pdf/vol.18_3/Art14.pdf).
- Eklund, L., Degerald, M., Brandt, M., Prishchepov, A. Pilesjö, P. (2017). How conflict affects land use: Agricultural activity in areas seized by the Islamic State. *Environmental Research Letters*, 12(5). DOI: 10.1088/1748-9326/aa673a
- Fang, Y., Shao, Z. (2022). The Russia-Ukraine conflict and volatility risk of commodity markets. *Finance Research Letters*, 50. DOI: <https://doi.org/10.1016/j.frl.2022.103264>.
- FAO (2022). The importance of Ukraine and the Russian Federation for global agricultural markets and the

- risks associated with the war in Ukraine. Information note 10 June 2022. <https://www.fao.org/3/cb9013en/cb9013en.pdf>.
- Gibson, G.R., Campbell, J.B., Zipper, C.E. (2015). Socio-political influences on cropland area change in Iraq, 2001–2012. *Applied Geography*, 62, 339–346. DOI: <https://doi.org/10.1016/j.apgeog.2015.05.007>.
- Hebryn-Baidy, L., Sakal, O., Tretiak, N., Kovalenko, A., Shtogryn, H., Kovalyshyn, O., Vrublevska, O. (2021). Cultivation of niche crops and prospects of eco-innovative agricultural production in Ukraine. *Acta Sci. Pol. Formatio Circumiectus*, 20(3–4), 29–46. DOI: <https://doi.org/10.15576/ASPFC/2021.20.3/4.29>.
- Kupchenko, A. (2022). Military food balances in Ukraine. Part 1. Production. Information and analytical agency "APK-Inform". <https://www.apk-inform.com/uk/exclusive/topic/1526079>.
- Libanova, E. et al. (2015). Revival of Donbas: Assessment of socio-economic losses and priority directions of state policy. Kyiv: NAS of Ukraine. [https://idss.org.ua/monografii/2016\\_dopov\\_Donbas.pdf](https://idss.org.ua/monografii/2016_dopov_Donbas.pdf).
- NULES (2018). Experts discussed the most acute problems of land use of the Armed Forces of Ukraine. 15 September 2018. <https://nubip.edu.ua/node/50147>.
- Pereira, P., Bašić, F., Bogunovic, I., Barcelo, D. (2022a). Russian-Ukrainian war impacts the total environment. *Science of the Total Environment*, 837. DOI: 10.1016/j.scitotenv.2022.155865.
- Pereira, P., Zhao, W., Symochko, L., Inacio, M., Bogunovic, I., Barcelo, D. (2022b). The Russian–Ukrainian armed conflict will push back the sustainable development goals. *Geography and Sustainability*, 3(3), 277–287. DOI: <https://doi.org/10.1016/j.geosus.2022.09.003>.
- Prohorovs, A. (2022). Russia's war in Ukraine: Consequences for European countries' businesses and economies. *Journal of Risk and Financial Management*, 15(7), 295. DOI: <https://doi.org/10.3390/jrfm15070295>.
- Ptoukha Institute for Demography and Social Studies of NAS of Ukraine (2022). Forecast assessment of the level of poverty in Ukraine in 2022 according to three scenarios of the development of socio-economic processes as a result of the Russian-Ukrainian war. Kyiv: Ptoukha Institute for Demography and Social Studies of NAS of Ukraine. <https://idss.org.ua/arhiv/%D0%9F%D1%80%D0%BE%D0%B3%D0%BD%D0%BE%D0%B7%20%D0%B1%D1%96%D0%B4%D0%BD%D0%BE%D1%81%D1%82%D1%96%202022%20.pdf>.
- Racioppi, F. et al. (2022). The impact of war on the environment and health: implications for readiness, response, and recovery in Ukraine. *The Lancet*, 400(10356), 871–873. DOI: [https://doi.org/10.1016/S0140-6736\(22\)01739-1](https://doi.org/10.1016/S0140-6736(22)01739-1).
- SESU (2022). Regarding demining by units of SESU. <https://dsns.gov.ua/map-demining>.
- SuperAgronom (2018). Donbas loses fertile lands due to mined fields. 21 April 2018. <https://superagronom.com/news/3906-cherez-zaminuvannya-donbas-vtrachaye-rodyuchi-zemli>.
- SuperAgronom (2022). The report on prices for grain and oilseeds in Ukraine has been published. 14 February 2022. <https://superagronom.com/news/14953-oprilyudneno-zvit-schodo-tsin-na-zernovi-ta-oliyni-kulturi-v-ukrayini>.
- Tollefson, J. (2022). What the war in Ukraine means for energy, climate, and food. *Nature*, 604(7905), 232–233. DOI: 10.1038/d41586-022-00969-9.
- UNCG (2022). Almost a third part of Ukrainian crops could be abandoned or inaccessible. 16 March 2022. <https://uncg.org.ua/en/almost-a-third-ua-crops/>.
- UNDDR (2023). Economic loss. <https://www.undrr.org/terminology/economic-loss>.
- UNHCR Ukraine (2022). Ukraine, other conflicts push forcibly displaced total over 100 million for first time. 23 May 2022. <https://www.unhcr.org/ua/en/45221-ukraine-other-conflicts-push-forcibly-displaced-total-over-100-million-for-first-time.html>.
- USDA (2022). Ukraine Agricultural Production and Trade. April 2022. <https://www.fas.usda.gov/sites/default/files/2022-04/Ukraine-Factsheet-April2022.pdf>.
- Vasyliuk, O., Norenko, K. (2016). The ATO territory will need large-scale reclamation after the end of the war. <http://epl.org.ua/environment/terytoriiia-ato-pislia-zavershennia-viiny-potrebutatyme-masshtabnoi-rekultyvatsii/>.
- Verkhovna Rada of Ukraine (2001). Land Code of Ukraine, ed. from 19/11/2022. <https://zakon.rada.gov.ua/laws/show/2768-14#Text>.
- Yin, H. et al. (2019). Agricultural abandonment and re-cultivation during and after the Chechen wars in the northern Caucasus. *Global Environmental Change*, 55, 149–159. DOI: 10.1016/j.gloenvcha.2019.01.005.
- Zhang, Z., Ding, J., Zhao, W., Liu, Y., Pereira, P. (2023). The impact of the armed conflict in Afghanistan on vegetation dynamics. *Science of The Total Environment*, 856. DOI: 10.1016/j.scitotenv.2022.159138.

## **OKREŚLENIE SZKÓD GOSPODARCZYCH NA UŻYTKACH ROLNYCH W ZWIĄZKU Z DZIAŁANAMI WOJSKOWYMI NA PRZYKŁADZIE TERYTORIUM REJONU KIJOWSKIEGO W UKRAINIE**

### **ABSTRAKT**

#### **Cel pracy**

Celem opracowania jest określenie strat ekonomicznych na gruntach rolnych (gruntach ornych), które zostały dotknięte działaniami wojennymi i wymagają dalszych działań w zakresie ich rozminowywania i przydatności do produkcji bezpiecznych produktów żywnościowych w celu przezwyciężenia ostrego kryzysu humanitarnego i żywnościowego.

#### **Materiał i metody**

Stosuje się ogólnie przyjęte metody badań naukowych: monograficzną, statystyczną, analityczną, porównawczą, interpolacyjną, prognostyczną, abstrakcyjno-logiczną, grawiurą.

#### **Wyniki i wnioski**

Straty ekonomiczne w wyniku działań wojennych obliczono na przykładzie gruntów rolnych (gruntów ornych) obwodu kijowskiego w Ukrainie. Rozważono aspekt przestrzenny przeprowadzonej w Ukrainie reformy administracyjno-terytorialnej w zakresie zmiany liczby powiatów i ich powierzchni. Reforma została przeprowadzona, by można było pracować z użyciem danych o gruntach rolnych zebranych zarówno dla nowego, jak i starego podziału administracyjno-terytorialnego obwodu kijowskiego. Rozważono przybliżony termin prac rozminowujących na terenach dotkniętych działaniami wojennymi, uwzględniając różny stopień intensywności ostrzału i złożoność tych prac. Obliczono niskie wyniki producentów rolnych w zakresie uprawy zbóż, roślin strączkowych i oleistych w obwodzie kijowskim. Dokonano kalkulacji strat ekonomicznych związanych z kosztami prac rozminowujących i niemożnością uprawy roślin rolniczych w obwodzie kijowskim. Wyniki uzyskane dla obwodu kijowskiego zostały interpolowane w celu określenia przybliżonej powierzchni gruntów ornych dotkniętych działaniami wojennymi i odpowiednio strat ekonomicznych na tych gruntach w całej Ukrainie.

**Słowa kluczowe:** produkcja roślinna, rozminowywanie, kryzys humanitarny i żywnościowy, zanieczyszczenie ziemi, powierzchnia upraw.