



Environmental Impacts of Food Loss and Waste: Land Degradation

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Food waste and loss have a negative impact on the environment, namely on water, land, energy and other natural resources used to produce non-consumable products. According to the results of an empirical study, the present study establishes the degree of land resource degradation resulting from food loss and waste and adequately identifies potential environmental benefits from reducing food loss and waste for agricultural land use would be discussed further. Methods: The authors' methodological approach for assessing the impact of food loss and waste on the degradation of land resources is based on the following principles: objectives, unity, systematicity, scientific knowledge, and maximum informativeness. In accordance with the purpose of the study and the above principles, an appropriate system of indicators has been developed. The methodology proposed by FAO in Ukraine was used to calculate food loss and waste. The obtained results are of great importance in the formation of food security policy based on sustainable land use development in Ukraine. First, it is empirically proven that zero food loss and waste on grains, potatoes, vegetables, fruits, meat and milk can significantly reduce the burden on land resources. Secondly, the reduction of food loss and waste has positive economic consequences.

1. Introduction

The Food and Agricultural Organization of the United Nations (FAO) (2020) defined food loss as “the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers”. In contrast, food waste “refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers”. Food loss and food waste are inter-woven and cross all tiers of the food chain. According to current estimates, worldwide more than 1 billion tons of food loss and waste are produced, while

almost 10% of the world's population suffers from malnutrition and food insecurity (Popat et al., 2020). At the same time, the volume of food loss and waste in the world is sufficient to feed 940 million adults (Abbate, 2020), which defines this problem as the main factor in the fight against hunger.

The problem of food loss and waste is extensively investigated by foreign scientists, in particular, in the EU and the US. The opinion of scientists is most divided as to which stage along the food chain, food loss and waste occurs, which affects the choice of the object of

research. Recently, modern researches have become increasingly interested and have made a slight shift in emphasising food loss and waste at the stages of retail trade and food consumption by households. In New Zealand, food waste in the retail sector was 13 kg per capita per year (Goodman-Smith et al., 2020). Sweden also pays special attention to retail (Rosenlund et al., 2020) and is active in finding preventive measures and incentives to reduce food waste at this stage of the food chain. In Italy, research is looking for tools to measure food waste (Amicarelli et al., 2020), in determining the degree of influence of food loss and waste management on the efficiency of retail operators (Alfiero et al., 2019) and in determining the behaviour of farmers concerning unsold food (Bonadonna et al., 2019). According to one study conducted in the United States (Dusoruth & Peterson, 2020), American households throw away a significant amount of food, which could be explained by the rather high standard of living of the average American. However, a similar situation is observed in developing countries. Studies conducted in Lebanon showed that food loss and waste at the household level is 0.2 kg per capita per day. In the world, annual food loss and waste at the household level are 1.3 billion tons (Pellegrini et al., 2019). Practical data shows that not all agricultural producers consider food loss and waste at the harvesting stage quite significant. Simultaneously, scientific research confirms that the volume of such losses is significant (Johnson et al., 2019). Economic losses resulting from food loss and waste at the harvesting stage are evidenced by the results of a study in Mozambique (Popat et al., 2020), which confirmed the loss of corn at a level of 3.7 to 7.9%, or 28 million dollars. That is almost 1% of the national budget, which is higher than the average cost of food aid programs received over the past three years. Losses at the stage of harvesting fruits and vegetables in the United States (North Carolina) amounted to 42% (Johnson et al., 2018). These results indicate a significant underestimation of significant volumes at the harvesting stage, which in some countries significantly exceeds losses at other stages.

Such findings show that the potential benefits of food loss and waste reduction are concentrated in three areas: environmental (rational use of resources to reduce anthropogenic pressure on the environment), social (increasing food availability, poverty and gender inequality eradication, especially in rural areas)

and economic (preventing economic losses, saving money and resources). It should be emphasised that all studies, regardless of the object of study (stages in the food chain), focus on the environmental, social and economic consequences of food loss and waste, but rarely simultaneously carry out an actual assessment of such consequences. An exception is the economic component, but it is not always present.

For Ukraine, this issue is of particular importance for several reasons. Firstly, Ukraine has joined other countries in implementing the Sustainable Development Goals 2016-2030 set by the United Nations. Secondly, Ukraine has one of the highest indicators among developed countries on the levels of land development and plots of land with an insufficient level of consumption of animal products. Thirdly, most agricultural producers, for example, during the former Soviet Union, still prefer extensive farming practices that create even more ecological burden on land resources without adequate economic and social returns. At the same time, a somewhat limited number of works are devoted to studies of food loss and waste in Ukraine; they determine the following problems: economic losses as a result of food loss and waste (Kotykova & Babych, 2019a), social consequences of food loss and waste (Kotykova & Babych, 2019b), food consumption by Ukrainian households depending on the affordability of food (Kotykova, Babych, & Pohorielova, 2020), the formation of criteria (Kotykova, Babych, & Yahodzinska, 2020) and a system of food security indicators (Kotykova, Babych, & Krylova, 2020) in accordance with the SDG 2030 criteria.

2. Materials and Methods

Our research focuses on the environmental aspects, particularly the impact of food loss and waste on the degradation of land resources in Ukraine. The study aims to establish the degree of degradation of land resources as a result of food loss and waste and identify potential environmental benefits for agricultural land usage from food loss and waste reduction (according to the results of an empirical study). The object of research is the environmental consequences of food loss and waste for agricultural land usage. The subject of the study includes indicators of land usage, inappropriate usage of crops area and arable land, population density, production volumes and food loss and waste per 100 hectares of agricultural land in the regions of

Ukraine and types of products (grains, vegetables, potatoes, meat, milk and fruits).

The research is based on empirical methods according to the authors' methodology in the estimation of the influence of food loss and waste on the level of land resources degradation. The methodological approach to assessing food loss and food losses is based on the principles of purpose, unity, consistency, scientific character and maximum information content (Kotyková, 2010). The hypothesis of the study is the assumption that food loss and waste leads to degradation of land resources while reducing food loss and waste has significant potential environmental benefits. The assessment of the agricultural land usage in Ukraine is based on the generally accepted methodology for analysing (Worldbank, 1998) the level of development of land (LDL, formula 1), the share of arable land in the area of agricultural land (SAL, formula 2) and the share of crops in arable land (SS_{ac} , formula 3):

$$LDL = \frac{AA_{grL}}{AL}, \quad (1)$$

where AA_{grL} - area of agricultural land, ha; AL - total area of land;

$$SAL = \frac{AA_{raL}}{AA_{grL}}, \quad (2)$$

where AA_{raL} - arable land area, ha;

$$SS_{ac} = \frac{AS_{ac}}{AA_{raL}}, \quad (3)$$

where SS_{ac} - share of crops in arable land, %.

In order to assess the impact of food loss and waste and land degradation, there was used the authors' approach based on the analysis of such indicators: volumes of food loss and waste, thousand tons; useless use of sown area of forage crops, thousand hectares; the proportion of the useless area used for sowing crops, %; useless use of arable land, thousands ha; share of useless arable land, %.

The methodology proposed by FAO (2011, p. 33-35) is used to calculate the total food loss and waste (FLW_{ac}) in Ukraine. The work "Economic Impact of Food Loss and Waste" shows the calculations on losses and waste of milk in Ukraine (2019a, p. 57) as an example.

The "useless use of the crop area" (UVA_{ac}) indicator for food loss and waste and loss for crops (grains, po-

tatoes and vegetables) is determined by the formula 4:

$$UVA_{ac} = \frac{FLW_{ac}}{PAC_{ac}}, \quad (4)$$

where FLW_{ac} - amount of food loss and waste and loss on crops or potatoes or vegetables; PAC_{ac} - yield of agricultural crops (grains, potatoes, vegetables), per 1 ha.

Indicator "Useless Use of Square Perennial Plants" (UVA_{pp}) for food loss and waste on fruits is determined by the formula 5:

$$UVA_{pp} = \frac{FLW_{pp}}{PAC_{pp}}, \quad (5)$$

where FLW_{pp} - volume of food loss and waste in terms of types of agricultural crops (grains, potatoes and vegetables); PAC_{pp} - yield of fruits, per 1 ha.

Indicator of "useless use of sown area of forage crops" (UVA_{meet}) for food loss and waste in meat is determined by the formula 6:

$$UVA_{meet} = \frac{FLW_{meet}}{MEEN_{1ha}}, \quad (6)$$

where FLW_{meet} - volume of food loss and waste in meat; $MEAT_{1ha}$ - amount of meat received per hectare of sown area of forage crops, per 1 hectare.

Indicator of "useless use of forage crop area" (UVA_{milk}) for food loss and waste and loss in milk is determined by the formula 7:

$$UVA_{milk} = \frac{FLW_{milk}}{MILK_{1ha}}, \quad (7)$$

where FLW_{milk} - volume of food loss and waste in milk; $MILK_{1ha}$ - amount of milk received per hectare of sown area of forage crops, per 1 hectare.

The official data of the State Statistics Service of Ukraine for 2016 served as the information base in terms of regions and types of products. According to previous studies (Babych, & Kovalenko, 2018), it is unfeasible to make calculations over a longer period, as the level of production and consumption of food

per capita in Ukraine over the past five years has practically not changed (Kotykova, & Babych, 2019a).

3. Results

Predominantly, degradation of land resources in Ukraine is the result of water and wind erosion caused by the high level of land tillage (60.7%) and agricultural land cultivation (85.6%) (Table 1). At the same time, in most regions, these indicators are even higher, in particular in the Volyn (69.4 and 90.7%), Donetsk (68.9 and 94.7%), Zhytomyr (67.0 and 87.8%), Ivano-Frankivsk (78.3 and 88.4%), Luhansk (72.8 and 96.6%), Odessa (72.3 and 92.7%), Poltava

(66.3 and 88.9%), Rivne (63.9 and 93.3%), Kharkiv (70.0 and 85.9%), Kherson (69.6 and 84.6%), Khmelnytskyi 62.6 and 93.8%), Cherkasy (71.9 and 82.0%), and Chernivtsi (63.0 and 94.2%) regions. Indicators in the Zaporizhzhia (30.4%), Kyiv (35.4%) and Sumy (39.4%) regions are the closest to the European indicators of land tillage level. By the level of the share of arable land in the area of agricultural land, only the Zaporizhzhia region (49.7%) has a value, which is close to one, common for the countries of the European Union. Thus, among the remaining (23) regions of Ukraine, there is no region where the share of arable land in the area of agricultural land was less than 71%.

Table 1. The level of use of agricultural land in Ukraine in 2016

Region	Area size of agricultural land, million hectares	Area of arable land, million hectares	Sowing area of agricultural crops, million hectares	Level of land tillage, %	Share of arable land in the area of agricultural land, %	Share of crops in arable land, %
Ukraine	34957.6	29931.2	27026.0	60.7	85.6	90.3
Vinnitsa	1838.2	1667.3	1642.2	60.7	85.6	90.3
Volyn	833.0	607.6	552.3	69.4	90.7	98.5
Dnipropetrovsk	2199.6	2082.6	1920.2	41.4	72.9	90.9
Donetsk	1777.1	1561.0	989.6	68.9	94.7	92.2
Zhytomyr	1290.4	1053.4	881.6	67.0	87.8	63.4
Zakarpattia	387.7	192.5	190.2	43.3	81.6	83.7
Zaporizhzhia	2127.1	1880.9	1630.2	30.4	49.7	98.8
Ivano-Frankivsk	493.5	377.7	371.4	78.3	88.4	86.7
Kyiv	1513.6	1280.2	1164.0	35.4	76.5	98.3
Kirovograd	1791.1	1730.3	1692.7	53.8	84.6	90.9
Luhansk	1706.0	1227.3	786.3	72.8	96.6	97.8
Lviv	1009.5	719.0	662.0	63.9	71.9	64.1
Mykolaiv	1777.2	1646.8	1533.4	46.2	71.2	92.1
Odesa	2207.5	1961.8	1846.2	72.3	92.7	93.1
Poltava	1837.0	1713.1	1719.6	66.3	88.9	94.1
Rivne	789.6	614.5	547.8	63.9	93.3	100.4
Sumy	1447.9	1159.7	1122.3	39.4	77.8	89.1
Ternopil	967.3	831.0	812.2	60.8	80.1	96.8
Kharkiv	2187.0	1851.1	1760.4	70.0	85.9	97.7
Kherson	1782.5	1672.6	1351.4	69.6	84.6	95.1
Khmelnytskyi	1484.2	1217.6	1153.2	62.6	93.8	80.8
Cherkasy	1316.8	1242.0	1194.9	71.9	82.0	94.7
Chernivtsi	442.6	322.1	305.7	63.0	94.3	96.2
Chernihiv	1751.2	1319.1	1196.2	54.7	72.8	94.9

Source: Authors computation based on State Statistics Service of Ukraine (2016)

The usage of arable land under crops is even higher. On average, in Ukraine, this indicator is 90.3%. At the same time, in Volyn (98.5%), Donetsk (92.2%), Zaporizhzhia (98.8%), Kyiv (98.3%), Kirovograd (90.9%), Luhansk (97.8%), Mykolaiv (92.1%), and Odesa (93.1%). Indicators in Chernivtsi (94.2%), Poltava (94.1%), Rivne (100.4%), Ternopil (96.8%), Kharkiv (97.7%), Kherson (95.1%), Cherkasy (94.7%), Chernivtsi (96.2%), and Chernihiv are even higher. Of course, there might be a situation where the arable land was used twice (repeated sowing, for example).

However, under such conditions, the volume of production loss and, consequently, the amount of "useless" usage of arable land would be even higher. Under such conditions, large areas of arable land are sown, but the products received for human consumption are not consumed or even lost, which is unacceptable. Thus, according to the calculations, the useless usage of grain sowing area in Ukraine in 2016 amounted to 670.7 thousand hectares, including 102.3 thousand hectares at the production stage, which is 4.7% of the total area arable land (Table 2).

Table 2. The useless use of the arable land in the grain crops production for food loss and waste and loss in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing area of grain crops, thousand hectares		Share of the sowing area of grain crops in the arable land, %		Share of the useless use of the sowing area of grain crops, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Ukraine	2548.9	371.6	670.7	102.3	47.9	45.7	4.7	100.0
Vinnitsa	303.0	33.2	56.5	6.2	52.0	48.6	6.5	8.4
Volyn	49.3	4.7	22.0	2.1	48.5	44.8	7.5	3.3
Dnipropetrovsk	37.7	15.8	18.6	7.8	52.5	51.6	1.7	2.8
Donetsk	46.6	9.2	19.6	3.9	34.8	33.6	3.6	2.9
Zhytomyr	133.9	12.9	29.0	2.8	37.1	34.4	7.4	4.3
Zakarpattia	15.6	1.1	9.3	0.7	47.8	42.9	10.1	1.4
Zaporizhzhia	72.1	14.0	32.4	6.3	46.9	45.2	3.7	4.8
Ivano-Frankivsk	35.8	3.4	11.2	1.1	40.1	37.1	7.4	1.7
Kyiv	190.4	21.1	36.5	4.0	44.3	41.4	6.4	5.4
Kirovograd	203.5	21.3	55.2	5.8	46.7	43.6	6.8	8.2
Luhansk	32.0	7.4	11.7	2.7	30.9	30.0	3.1	1.7
Lviv	71.4	6.9	22.3	2.2	42.3	39.1	7.3	3.3
Mykolaiv	59.5	13.5	26.3	6.0	50.7	49.1	3.2	3.9
Odesa	103.7	23.7	37.4	8.5	61.0	59.1	3.1	5.6
Poltava	339.4	34.1	66.4	6.7	54.6	50.7	7.1	9.9
Rivne	35.8	6.3	11.0	1.9	43.9	42.1	4.1	1.6
Sumy	221.7	25.6	40.0	4.6	55.7	52.2	6.2	6.0
Ternopil	85.6	13.7	20.7	3.3	56.0	53.5	4.5	3.1
Kharkiv	96.8	21.6	31.4	7.0	53.1	51.4	3.2	4.7
Kherson	41.9	9.9	20.0	4.7	39.7	38.5	3.0	3.0
Khmelnyskiy	189.6	19.2	37.6	3.8	43.9	40.8	7.0	5.6
Cherkasy	203.3	25.8	37.1	4.7	53.1	50.1	5.6	5.5

Continue Table 2. The useless use of the arable land in the grain crops production for food loss and waste and loss in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing area of grain crops, thousand hectares		Share of the sowing area of grain crops in the arable land, %		Share of the useless use of the sowing area of grain crops, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Chernivtsi	3.7	1.3	2.4	0.9	38.0	37.3	2.0	0.4
Chernihiv	87.0	25.5	15.9	4.7	49.6	48.4	2.4	2.4

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

The indicators in Volyn (7.5%), Zhytomyr (7.4%), Zaporizhzhia (10.1%), Ivano-Frankivsk (7.4%), Luhansk (7.3 %), Poltava (7.1%) and Khmelnytskyi (7.0%) regions are higher in one-and-a-half times and more, in comparison with the average data on the volumes of useless arable land in Ukraine. It should be noted that there is a correlation between the regions with the highest levels of food loss and waste of grain and the highest rates of useless usage of grain sown area. At the same time, this correspondence is not established when comparing data of ordinary regions and regions with the highest proportion of grain area useless usage. This is due to two factors: significant differences in the volumes of grain crops by region and different grain yields.

The highest level of useless usage of arable land under the crops is in the Vinnytsa, Kirovograd and Poltava regions, respectively 8.4, 8.2 and 9.9%; the lowest level is in Zhytomyr, Ivano-Frankivsk, Rivne and Chernivtsi, respectively 1.4, 1.7, 1.6 and 0.4%.

In case of the removal of useless areas of grain crops, the share of their crop area will decrease to 45.7%, which is 2.2 % less than actual data. This difference is even higher in Vinnytsa, Volyn, Zhytomyr, Zakarpattia, Zaporizhzhia, Ivano-Frankivsk, Kyiv, Kirovograd, Lviv, Poltava, Sumy, Khmelnytskyi and Cherkasy regions.

Regarding the inappropriate usage of arable land in the cultivation of potatoes, it is established that the total amount of irrationally used area of sowing in Ukraine

is 285.3 thousand hectares, including 114.8 thousand hectares at the production stage (Table 3). In terms of regions, the largest areas of the useless area of arable land under potato crops are located in the Vinnytsia and Kyiv regions, and the smallest are in the Zakarpattia, Zaporizhzhia, Mykolaiv and Kherson regions. Thus, the share of uselessly consumed arable land under potato crops in Ukraine was 21.8%, including more than 30.0% in the Dnipropetrovsk, Donetsk, Zaporizhzhia and Luhansk regions and less than 20.0% in the Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Poltava, Ternopil, Khmelnytskyi and Chernihiv regions. According to the actual data, the share of potatoes in the area of arable land in Ukraine is 4.4%. The share of crops in the Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions is much higher than this indicator (more than 10%), and it is twice less for the Zaporizhzhia, Luhansk, Mykolaiv, Odesa and Kherson regions. In case of the removal of useless areas of potatoes, the share of sowing in the total area of arable land will decrease to 3.4% (by 1.0%), while in Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions, the reduction of the share of potatoes in the arable land will be more than 2.0%.

Regarding the inappropriate usage of arable land in vegetable growing, it is established that the total amount of irrationally used area of sowing in Ukraine is 145.2 thousand hectares, including 39.1 thousand hectares at the production stage (Table 4). From a perspective of regions, the largest areas of the useless usage of arable land under vegetable crops are situated in the Dnipropetrovsk, Kyiv and Kherson regions,

Table 3. The useless use of the arable land in the potatoes production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing area of potatoes, thousand hectares		Share of the sowing area in the arable land, %		Share of the useless use of the sowing area of potatoes, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Ukraine	4645.4	1903.2	285.3	114.8	4.4	3.4	21.8	100.0
Vinnitsa	375.8	161.7	22.0	9.5	6.5	5.2	20.3	7.7
Volyn	188.6	99.1	12.0	6.3	11.8	9.9	16.7	4.2
Dnipropetrovsk	182.5	52.7	16.2	4.7	2.6	1.8	30.3	5.7
Donetsk	154.6	35.8	13.5	3.1	2.3	1.4	37.8	4.7
Zhytomyr	285.4	115.2	15.1	6.1	6.6	5.2	21.7	5.3
Zakarpattia	104.9	46.8	6.6	3.0	17.6	14.1	19.6	2.3
Zaporizhzhia	82.5	23.1	6.9	1.9	1.2	0.8	31.3	2.4
Ivano-Frankivsk	193.8	85.3	11.8	5.2	15.7	12.6	19.9	4.1
Kyiv	505.3	149.0	28.2	8.3	7.4	5.2	29.7	9.9
Kirovograd	157.7	52.8	10.6	3.6	2.4	1.7	26.1	3.7
Luhansk	99.8	22.1	6.8	1.5	1.4	0.8	39.5	2.4
Lviv	299.5	141.7	17.4	8.2	13.1	10.6	18.5	6.1
Mykolaiv	79.7	23.5	5.6	1.7	1.2	0.8	29.7	2.0
Odesa	137.6	47.3	9.3	3.2	1.9	1.4	25.4	3.2
Poltava	174.1	93.2	8.9	4.7	3.2	2.6	16.3	3.1
Rivne	214.0	109.3	12.0	6.1	11.4	9.4	17.1	4.2
Sumy	227.2	93.2	12.3	5.0	5.0	3.9	21.3	4.3
Ternopil	176.4	86.4	10.5	5.1	7.1	5.8	17.9	3.7
Kharkiv	243.1	94.3	13.9	5.4	3.3	2.6	22.6	4.9
Kherson	75.3	24.5	6.4	2.1	1.4	1.0	26.9	2.2
Khmelnyskiy	235.0	115.5	11.7	5.8	5.4	4.4	17.8	4.1
Cherkasy	178.5	73.4	10.9	4.5	4.1	3.2	21.3	3.8
Chernivtsi	124.0	52.0	7.1	3.0	10.5	8.3	20.9	2.5
Chernihiv	150.4	105.2	9.9	7.0	6.0	5.3	12.5	3.5

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

and the smallest are in the Sumy, Khmelnytskyi and Chernihiv regions. Consequently, the share of uselessly used arable crops in Ukraine was 32.5%, including the Donetsk, Kyiv and Luhansk regions with more than 40%, and the Vinnitsia, Volyn, Dnipropetrovsk, Kirovograd, Poltava, Kharkiv, Kherson and Cherkasy with less than 30%. According to the actual data, the share of vegetables sown in the area of arable land in Ukraine is 15%. Per the given indicator

(more than 2%) is the share of crops in the Volyn, Ivano-Frankivsk, Kyiv, Lviv, Kherson and Chernivtsi regions, and smaller than the given indicator (less than 1%) in the Luhansk, Sumy, Khmelnytskyi and Chernivtsi regions. In case of removing the useless areas of vegetable sowing, the share of sowing of the crop in the total area of arable land will decrease to 1.0% (by 0.5%). In contrast, in the Zakarpattia and Kharkiv regions, the reduction of the share of vegetables sown

in the arable land will be more than 1.5%.

Regarding the inappropriate use of farmland in the cultivation of fruits, it has been established that the total amount of irregularly used area in Ukraine is 87.4 thousand hectares, including 17.2 thousand hectares

at the production stage. In terms of regions, the largest areas of useless agricultural area used in fruits and vegetable production are installed in the Vinnytsa, Dnipropetrovsk, Kyiv, Lviv and Chernivtsi regions, and the smallest in Zhytomyr, Rivne and Sumy regions. Thus, the share of useless usage of fruit farmland in

Table 4. The useless use of the arable land in the vegetables production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the sowing vegetables, thousand hectares		Share of the sowing area in the arable land, %		Share of the useless use of the sowing area of vegetables, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Ukraine	3155.3	874.8	145.2	39.1	1.5	1.0	32.5	100.0
Vinnytsa	148.1	44.4	6.3	1.9	1.3	0.9	29.2	4.4
Volyn	82.3	25.3	3.8	1.2	2.2	1.6	28.5	2.6
Dnipropetrovsk	223.1	67.0	10.4	3.1	1.7	1.2	29.1	7.2
Donetsk	164.5	20.0	10.7	1.3	1.0	0.3	72.1	7.4
Zhytomyr	91.6	26.2	3.6	1.0	1.1	0.8	30.6	2.5
Zakarpattia	81.8	23.4	3.9	1.1	6.7	4.6	30.6	2.7
Zaporizhzhia	136.0	38.2	5.6	1.6	1.0	0.7	31.1	3.8
Ivano-Frankivsk	64.4	15.1	3.9	0.9	2.8	1.7	37.4	2.7
Kyiv	259.6	56.1	11.6	2.5	2.2	1.3	40.5	8.0
Kirovograd	75.0	22.4	5.0	1.5	1.0	0.7	29.3	3.4
Luhansk	73.7	15.8	3.8	0.8	0.8	0.5	40.9	2.6
Lviv	169.1	44.2	8.5	2.2	3.5	2.4	33.4	5.8
Mykolaiv	163.1	46.2	5.9	1.7	1.2	0.8	30.9	4.1
Odesa	141.7	33.3	9.1	2.1	1.2	0.8	37.3	6.2
Poltava	150.8	47.8	6.8	2.1	1.4	1.0	27.6	4.7
Rivne	72.3	20.7	3.7	1.1	2.0	1.4	30.6	2.5
Sumy	63.2	18.2	3.2	0.9	0.9	0.6	30.3	2.2
Ternopil	78.0	22.7	3.5	1.0	1.4	1.0	30.1	2.4
Kharkiv	211.5	66.4	8.5	2.7	1.7	1.2	27.9	5.9
Kherson	390.0	131.6	10.6	3.6	2.4	1.8	25.9	7.3
Khmelnytskyi	70.4	20.0	3.4	1.0	0.9	0.6	30.7	2.4
Cherkasy	106.3	32.2	5.9	1.8	1.7	1.2	28.9	4.1
Chernivtsi	76.2	20.8	3.9	1.1	3.8	2.6	32.1	2.7
Chernihiv	62.6	16.8	3.5	0.9	0.8	0.5	32.5	2.4

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

Ukraine was 44.4%, including in Kiev, Luhansk, Sumy and Chernihiv regions with more than 60%, and in Vinnitsa, Zakarpattia, Lviv, Odessa, Poltava, Rivne, Ternopil, Kherson, Khmelnytskyi and Chernivtsi with less than 40% (Table 5).

According to the present data, the share of fruit and vegetables in fruit-bearing age in the area of agricul-

tural lands in Ukraine is 0.7%. The share of fruit trees in the Zakarpattia and Chernivtsi regions is higher than the corresponding figure (more than 3%) and is smaller (less than 0.3%) in Sumy and Chernihiv. With the exception of the useless usage of planting areas in the fruiting age, the share of plantings in the fruiting age in the total area of agricultural lands will decrease to 0.4% (by 0.3%). In contrast, in the Zakarpattia and

Table 5. The useless use of the farmland in the fruits and vegetables production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the perennial plantings area, thousand hectares		Share of the plantations in the fruiting age in the arable land, %		Share of the useless use of the plantations in the fruiting age, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Ukraine	984.8	208.7	87.4	17.2	0.7	0.4	44.4	100.0
Vinnitsa	88.7	23.9	7.2	1.9	1.2	0.8	32.5	8.2
Volyn	17.3	3.3	2.2	0.4	0.6	0.3	46.4	2.5
Dnipropetrovsk	62.9	13.5	5.5	1.2	0.6	0.4	40.7	6.2
Donetsk	42.8	7.9	3.1	0.6	0.4	0.2	47.3	3.5
Zhytomyr	18.0	3.7	1.6	0.3	0.3	0.2	43.1	1.8
Zakarpattia	47.4	13.4	3.8	1.1	3.2	2.2	30.9	4.4
Zaporizhzhia	31.3	5.9	3.7	0.7	0.4	0.2	46.6	4.2
Ivano-Frankivsk	22.5	4.3	3.9	0.7	1.7	0.9	45.5	4.4
Kyiv	95.7	6.3	11.6	0.8	0.6	-0.2	133.8	13.3
Kirovograd	15.5	2.7	2.5	0.4	0.3	0.1	50.5	2.8
Luhansk	20.8	2.4	3.6	0.4	0.3	0.1	75.9	4.2
Lviv	43.2	9.5	5.0	1.1	1.2	0.8	39.6	5.7
Mykolaiv	36.8	7.7	2.0	0.4	0.3	0.2	42.1	2.3
Odesa	113.7	27.7	2.9	0.7	0.4	0.2	35.9	3.3
Poltava	28.3	6.9	2.0	0.5	0.3	0.2	35.8	2.3
Rivne	22.8	6.8	1.9	0.6	0.8	0.6	29.3	2.2
Sumy	10.6	1.4	1.9	0.3	0.2	0.1	67.1	2.2
Ternopil	25.8	6.4	2.1	0.5	0.6	0.4	35.0	2.4
Kharkiv	49.5	6.9	3.9	0.5	0.3	0.1	62.6	4.5
Kherson	35.0	8.0	2.8	0.6	0.4	0.3	38.4	3.2
Khmelnytskyi	60.6	17.6	4.2	1.2	1.0	0.7	30.1	4.9
Cherkasy	25.0	4.5	2.6	0.5	0.4	0.2	48.7	3.0
Chernivtsi	61.0	16.7	5.1	1.4	3.6	2.5	31.9	5.8
Chernihiv	9.6	1.3	2.1	0.3	0.2	0.1	64.9	2.4

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

Chernivtsi regions, the reduction in the proportion of fruit plantings in agricultural land area will be more than 1.0%.

Regarding the inappropriate usage of arable land in the production of meat, it has been established that the total amount of uselessly used area of sowings of

forage crops in Ukraine is 699.3 thousand hectares, including 61.8 thousand hectares at the production stage (Table 6). In terms of regions, the largest areas of the useless usage of arable land under sowings of forage crops in the production of meat are installed in Zhytomyr, Poltava, Kharkiv and Chernihiv regions, and the smallest in the Zakarpattia, Kirovograd and

Table 6. The useless use of the arable land in the meat production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the forage crops area, thousand hectares		Share of the forage crops area in the arable land, %		Share of the useless use of the sowing crops area, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Ukraine	816.9	74.3	699.3	61.8	6.5	4.1	36.2	100.0
Vinnitsa	85.7	10.4	36.3	4.4	8.2	6.1	26.4	5.2
Volyn	31.5	3.9	23.0	2.8	14.7	10.9	25.7	3.3
Dnipropetrovsk	87.7	7.7	21.5	1.9	2.8	1.8	36.6	3.1
Donetsk	58.2	2.8	30.1	1.4	2.9	0.9	67.5	4.3
Zhytomyr	16.4	1.7	44.0	4.6	13.6	9.4	30.8	6.3
Zakarpattia	15.5	1.6	13.1	1.4	22.5	15.7	30.2	1.9
Zaporizhzhia	25.1	1.8	21.4	1.5	2.6	1.4	44.0	3.1
Ivano-Frankivsk	23.0	2.6	22.3	2.5	20.6	14.7	28.8	3.2
Kyiv	91.9	6.4	38.9	2.7	6.6	3.5	46.3	5.6
Kirovograd	16.2	1.7	14.2	1.5	2.6	1.8	31.1	2.0
Luhansk	18.3	0.7	22.6	0.9	2.1	0.3	86.3	3.2
Lviv	45.7	3.9	37.2	3.2	13.9	8.7	37.2	5.3
Mykolaiv	12.7	1.0	25.6	2.0	3.8	2.2	41.0	3.7
Odesa	25.1	1.5	33.7	2.0	3.2	1.4	54.3	4.8
Poltava	27.7	2.6	42.7	4.0	7.2	4.7	34.5	6.1
Rivne	17.5	1.8	31.4	3.2	16.0	10.9	31.8	4.5
Sumy	15.2	1.5	26.5	2.6	6.8	4.5	33.4	3.8
Ternopil	18.4	1.7	21.5	2.0	7.4	4.8	35.0	3.1
Kharkiv	39.8	3.0	41.4	3.1	5.3	3.1	41.9	5.9
Kherson	15.3	1.3	26.7	2.3	4.3	2.7	36.9	3.8
Khmelnyskiy	21.2	2.1	34.8	3.4	8.9	6.0	32.1	5.0
Cherkasy	80.2	10.4	23.4	3.0	7.6	5.7	24.8	3.4
Chernivtsi	13.6	1.3	16.3	1.6	15.6	10.6	32.4	2.3
Chernihiv	14.9	1.1	50.9	3.8	9.2	5.4	41.9	7.3

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

Chernivtsi regions. Thus, the share of inefficient arable land under crop sowings in meat production in Ukraine was 36.2%, including more than 50% in Donetsk, Luhansk and Odesa regions and less than 30% in Vinnytsa, Volyn, Ivano-Frankivsk and Cherkassy. According to the data, the share of crop sowing area in arable land in Ukraine is 6.5%. The share of crops in the Volyn, Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions is higher than in the given indicator (more than 10%), and smaller (less than 3%) in Dnipropetrovsk, Donetsk, Zaporizhzhia, Kirovograd and Luhansk. In case of the removal of useless usage of forage crops areas in the production of meat, the share of sowing of culture in the total area of arable land will decrease to 4.1% (by 2.4%), while in the Zakarpattia, Ivano-Frankivsk, Lviv, Rivne and Chernivtsi regions, decreasing the share of fodder crops sowing in the area of arable land will be more than 5.0%.

Regarding the inappropriate usage of arable land in

the production of milk, it is established that the total amount of irrationally used area of sowing of fodder crops in Ukraine is 322.0 thousand hectares, including 70.1 thousand hectares at the production stage (Table 7). In terms of regions, the largest areas of the useless area of arable land under sowing of forage crops in the production of milk are installed in the Kyiv and Kharkiv regions, and the smallest in the Zakarpattia, Kirovograd and Chernivtsi regions. Thus, the share of inefficient arable land under crop sowing in milk production in Ukraine was 16.7%, including more than 30% Donetsk, Kyiv and Luhansk regions, and less than 13% in Volyn, Zakarpattia, Ivano-Frankivsk, Rivne and Chernivtsi. In case of the removal of useless usage of forage crops areas in the production of milk, the share of sowing of culture in the total area of arable land will decrease to 5.4% (by 1.1%), while in Ivano-Frankivsk, Lviv and Chernivtsi regions, the reduction in the share of fodder crops in the arable land will be more than 2.0%.

In general, in Ukraine, taking into account useless

Table 7. The useless use of the arable land in the milk production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the forage crops area, thousand hectares		Share of the forage crops area in the arable land, %		Share of the useless use of the sowing crops area, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Ukraine	1715.3	376.5	322.0	70.1	6.5	5.4	16.7	100.0
Vinnytsa	120.7	31.0	19.4	5.0	8.2	7.1	14.1	6.0
Volyn	48.5	15.0	10.5	3.2	14.7	13.0	11.8	3.3
Dnipropetrovsk	87.7	11.6	16.1	2.1	2.8	2.0	27.4	5.0
Donetsk	80.8	7.0	18.7	1.6	2.9	1.7	41.9	5.8
Zhytomyr	74.4	20.6	18.8	5.2	13.6	11.8	13.1	5.8
Zakarpattia	40.0	11.6	5.4	1.6	22.5	19.7	12.5	1.7
Zaporizhzhia	51.8	9.4	9.7	1.8	2.6	2.1	20.0	3.0
Ivano-Frankivsk	60.3	16.9	10.0	2.8	20.6	17.9	12.9	3.1
Kyiv	132.7	15.9	25.5	3.1	6.6	4.6	30.3	7.9
Kirovograd	45.7	11.2	6.8	1.7	2.6	2.2	14.9	2.1
Luhansk	39.4	4.5	8.3	1.0	2.1	1.5	31.8	2.6
Lviv	85.8	19.7	15.8	3.6	13.9	11.7	15.8	4.9
Mykolaiv	55.7	12.4	10.2	2.3	3.8	3.2	16.3	3.2

Continue Table 7. The useless use of the arable land in the milk production for food loss and waste in Ukraine in 2016

Region	The volume of food loss and waste, thousand tons		The useless use of the forage crops area, thousand hectares		Share of the forage crops area in the arable land, %		Share of the useless use of the sowing crops area, %	
	total	incl. at the stage of the agricultural production	total	incl. at the stage of the agricultural production	fact	if removing the useless sowing areas	by region	total amount in Ukraine
Odesa	66.0	13.2	11.3	2.3	3.2	2.6	18.2	3.5
Poltava	115.6	28.9	17.9	4.5	7.2	6.2	14.5	5.6
Rivne	52.7	15.9	11.9	3.6	16.0	14.1	12.1	3.7
Sumy	62.7	15.0	12.0	2.9	6.8	5.8	15.1	3.7
Ternopil	60.0	16.4	8.1	2.2	7.4	6.4	13.2	2.5
Kharkiv	114.4	19.2	21.4	3.6	5.3	4.2	21.6	6.6
Kherson	46.8	10.7	11.4	2.6	4.3	3.6	15.8	3.5
Khmelnyskiy	77.2	21.4	14.2	3.9	8.9	7.7	13.1	4.4
Cherkasy	83.2	18.8	15.2	3.4	7.6	6.4	16.0	4.7
Chernivtsi	36.9	10.4	6.5	1.8	15.6	13.6	12.9	2.0
Chernihiv	76.4	19.9	16.9	4.4	9.2	7.9	13.9	5.3

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

arable land usage in the production of crops, potatoes, vegetables, fruits, meat and milk, the total area of irrational used arable land is 2122.4 thousand hectares (7.1% of the total area of arable land) (Table 8). Almost half of this area is inappropriately used arable land of eight regions: Vinnytsa, Zhytomyr, Kyiv, Lviv, Odesa, Poltava, Kharkiv and Khmelnytskyi. The lowest rates (less than seventy thousand hectares) of useless arable land usage were established in six regions: Zakarpattia, Ivano-Frankivsk, Luhansk, Rivne, Ternopil and Chernivtsi. It should be noted that if the Zakarpattia region in the absolute value has the least value of useless arable land (38.5 thousand hectares), then in relative terms it prevails in all other regions of Ukraine with 20% of arable land of inefficient use. More than seven regions (Volyn, Zhytomyr, Zakarpattia, Ivano-Frankivsk, Kiev, Lviv, Rivne, Chernivtsi) have more than 10% of arable land, which is uselessly used, and only five regions (Dnipropetrovsk, Zaporizhzhia, Luhansk, Mykolaiv, Kherson) have an indicator less than 5% of irrationally used area of crops from in the total area of arable land.

Table 9 calculations confirm the hypothesis that the

negative impact of food loss and waste on arable land usage is significant. Thus, removing useless arable land usage will decrease the share of arable land in agricultural area by 6.0% – from 85.6 to 79.6%. In 13 regions, this difference will be even greater, and in the Zakarpattia, Lviv and Ivano-Frankivsk regions the decrease will be respectively 10, 10 and 12%. It is logical to assume that in those regions where the population density is higher, food loss and waste will be greater, such as in Zakarpattia, Ivano-Frankivsk, Lviv and Chernivtsi regions. At the same time, Zakarpattia and Chernivtsi regions have one of the smallest indicators of production per 100 hectares of agricultural land.

However, such a conclusion is not always reliable, as the provision of the regions with agricultural land is different. In addition, the level of yield and structure of crops are also significantly different, as evidenced by the data of Donetsk region, which, according to the population density, ranks 4th among the regions of Ukraine and, 23rd in loss of food loss and waste per 100 hectares of agricultural land. At the same time, the Donetsk region occupies the penultimate position among Ukraine regions by volume of production per

100 hectares of agricultural land. Similarly, in the regions with the lowest population density the lowest food loss and waste per 100 hectares (Mykolaiv and Kherson regions) or the smallest share in the total amount of losses in Ukraine (Kirovograd and Chernihiv regions) are observed in the regions with the lowest population density).

The calculations confirm the thesis of the significant potential benefits of reducing food loss and waste, particularly as a strategy to meet the food deficit, which is projected to occur in 2050 with 9.3 billion people. The main potential environmental benefits of

reducing land degradation by reducing food loss and waste in Ukraine are shown in Figure 1.

4. Discussion

Domestic scientists devote insufficient attention to this problem: Ukraine does not have full-scale studies of food loss and waste at the regional or national level. Undoubtedly, scholarly works deal with certain aspects of the problem under the study, but they are local and unsystematic. There is no study of the impact of food loss and waste on the level of degradation of land resources in Ukraine. Consequently, the over-

Table 8. The useless use of the arable land for food loss and waste in Ukraine

Region	The usage of the arable land in the production of the agricultural products			Share of the arable land in the agricultural land, %	
	Actually – total, million hectares	The useless use of the arable land, thousand hectares	Share of the useless use of the arable land, %	Fact	If removing the useless arable land
Ukraine	29931.2	2122.4	7.1	85.6	79.6
Vinnitsa	1667.3	140.5	8.4	90.7	83.1
Volyn	607.6	71.2	11.7	72.9	64.4
Dnipropetrovsk	2082.6	82.8	4.0	94.7	90.9
Donetsk	1561.0	92.6	5.9	87.8	82.6
Zhytomyr	1053.4	110.4	10.5	81.6	73.1
Zakarpattia	192.5	38.5	20.0	49.7	39.7
Zaporizhzhia	1880.9	75.8	4.0	88.4	84.9
Ivano-Frankivsk	377.7	59.3	15.7	76.5	64.5
Kyiv	1280.2	140.6	11.0	84.6	75.3
Kirovograd	1730.3	91.8	5.3	96.6	91.5
Luhansk	1227.3	53.3	4.3	71.9	68.8
Lviv	719.0	101.2	14.1	71.2	61.2
Mykolaiv	1646.8	73.7	4.5	92.7	88.5
Odesa	1961.8	100.6	5.1	88.9	84.3
Poltava	1713.1	142.7	8.3	93.3	85.5
Rivne	614.5	69.9	11.4	77.8	69.0
Sumy	1159.7	93.9	8.1	80.1	73.6
Ternopil	831.0	64.3	7.7	85.9	79.3
Kharkiv	1851.1	116.6	6.3	84.6	79.3
Kherson	1672.6	75.1	4.5	93.8	89.6
Khmelnyskiy	1217.6	101.7	8.4	82.0	75.2
Cherkasy	1242.0	92.5	7.4	94.3	87.3
Chernivtsi	322.1	36.2	11.2	72.8	64.6
Chernihiv	1319.1	97.2	7.4	75.3	69.8

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

whelming majority of scientific works studying food loss and waste one way or another belong to a foreign scientific school. However, in the global food loss and waste calculations conducted by FAO, Ukraine does not appear to be a separate country but classified as "Europe". It is quite evident that the averaged indicators of this group are not close to the realities of Ukraine. Therefore, proposals for reducing food loss and waste developed based on such analytical data, cannot fully represent our country, which requires the corresponding calculations according to actual data

(Babych, 2018).

5. Conclusions

The study concluded that the loss of food loss and waste has significant negative environmental consequences on land use. Thus, the amount of inadequately expended area of sowing of agricultural crops is 670.7 thousand hectares of grain crops; 285.3 thousand hectares of potatoes; 145.2 thousand hectares of vegetable crops; 87.4 thousand on plantations of perennial

Table 9. The volume of production and food loss and waste per 100 hectares of agricultural land in Ukraine in 2016

Region	Estimated per 100 hectares of agricultural land:						
	population density		produced products		food loss and waste		
	million people	in % in relation to the data in Ukraine	thousand kcal	in % in relation to the data in Ukraine	thousand kcal	in % in relation to the data in Ukraine	in % to the volume of production in the region
Ukraine	113.4	100.0	657.2	100.0	12.2	100.0	1.9
Vinnnytsa	86.5	76.3	1109.4	168.8	19.7	161.5	1.8
Volyn	125.0	110.2	472.0	71.8	16.1	131.5	3.4
Dnipropetrovsk	146.9	129.5	451.8	68.7	8.6	70.4	1.9
Donetsk	238.8	210.6	317.6	48.3	5.6	45.5	1.8
Zhytomyr	96.1	84.8	650.4	99.0	14.2	116.3	2.2
Zakarpattia	324.7	286.3	389.5	59.3	20.2	165.2	5.2
Zaporizhzhia	81.8	72.1	384.3	58.5	5.7	46.3	1.5
Ivano-Frankivsk	279.6	246.6	615.8	93.7	22.3	182.3	3.6
Kyiv	114.6	101.1	888.3	135.2	18.2	148.9	2.0
Kirovograd	53.9	47.5	677.7	103.1	9.2	75.0	1.4
Luhansk	128.7	113.5	253.9	38.6	3.9	32.0	1.5
Lviv	251.0	221.4	569.6	86.7	19.6	160.7	3.4
Mykolaiv	64.7	57.1	447.7	68.1	7.0	57.5	1.6
Odesa	108.1	95.3	621.3	94.5	9.1	74.4	1.5
Poltava	77.7	68.5	1076.1	163.7	15.5	126.9	1.4
Rivne	147.3	129.9	605.0	92.1	18.5	151.1	3.1
Sumy	76.3	67.3	1017.8	154.9	14.7	120.3	1.4
Ternopil	109.5	96.6	880.9	134.0	16.8	137.4	1.9
Kharkiv	123.5	108.9	603.2	91.8	10.9	88.8	1.8
Kherson	59.2	52.2	376.9	57.4	9.3	76.3	2.5
Khmelnyskiy	86.6	76.4	799.7	121.7	15.0	122.4	1.9
Cherkasy	93.5	82.5	1160.2	176.5	17.3	141.6	1.5
Chernivtsi	205.2	180.9	376.7	57.3	18.9	154.5	5.0
Chernihiv	59.0	52.0	847.8	129.0	12.7	104.0	1.5

Source: Authors computation 2019 based on State Statistics Service of Ukraine (2016)

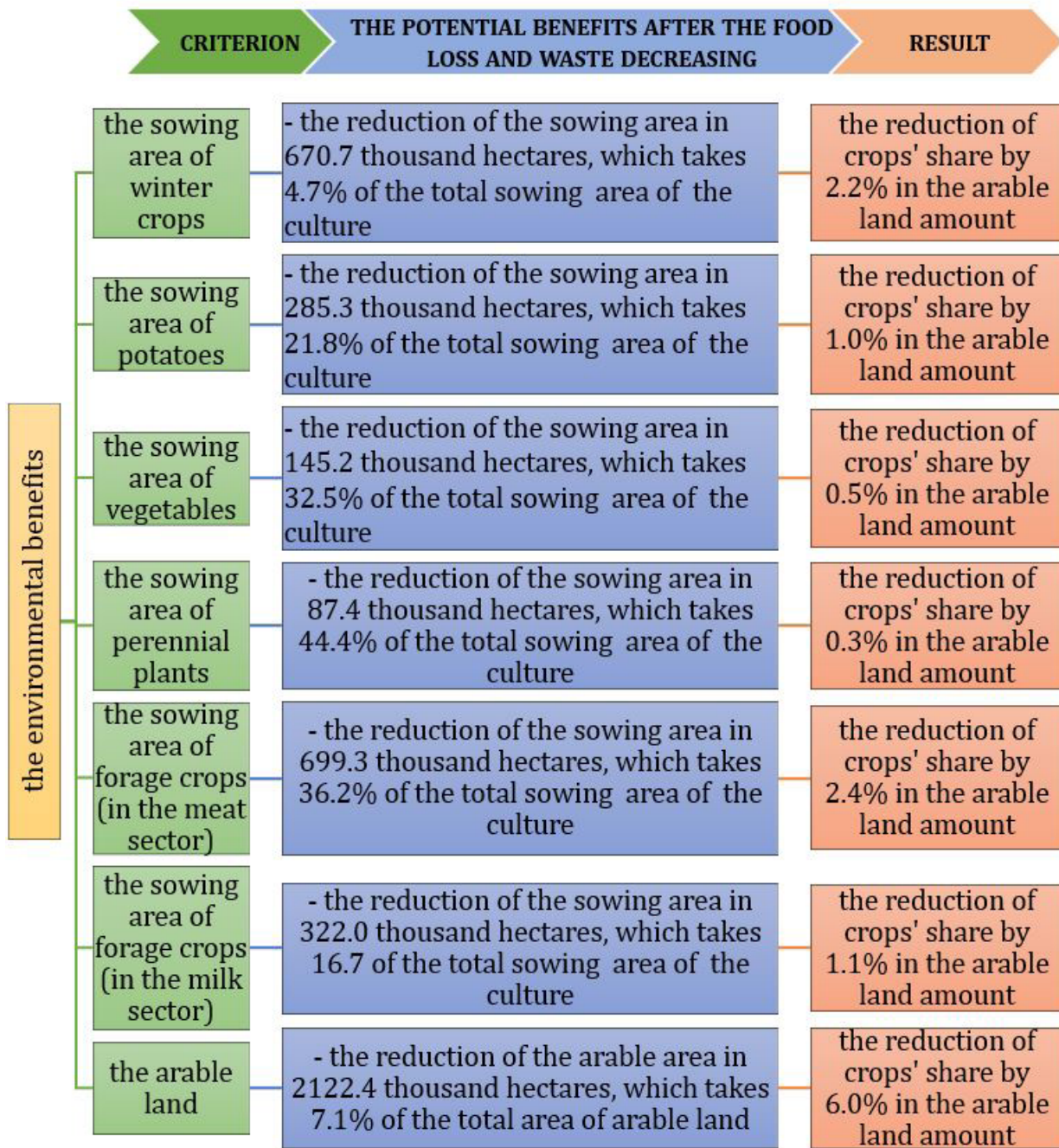


Figure 1. The potential environmental benefits on the reduction of land degradation after decreasing the food loss and waste in Ukraine. (Source: Authors work)

herbs; 699.3 and 322.0 thousand hectares of fodder crops for the production of meat and milk respectively. Thus, the total area of inefficient arable land is 2122.4 thousand hectares (7.1% of the total area of arable land). Under the condition that the useless areas of arable land are removed, the share of arable land in agricultural lands will decrease by 6.0%.

The obtained results are of great importance in forming food security policy based on sustainable land use

development in Ukraine. First, it is empirically proven that zero losses of food loss and waste on grain, potatoes, vegetables, fruits, meat and milk can significantly reduce the pressure on land resources. Secondly, reducing food loss and waste has positive economic consequences. Reducing crop areas means cutting crop costs while preserving production volume for implementation, which adds value-added. This conclusion is especially important for agricultural producers, the vast majority of whom believe that additional

profit can be obtained using extensive (through the expansion of cultivated areas) or intensive (through increasing the usage of mineral fertilisers and plant protection products) methods of farming.

Taking into account the experience of developed countries that have achieved certain successes in food loss and waste problems, Ukraine will benefit from the practice of special digital platforms (Cane & Parra, 2020); resource efficiency and food waste reduction in the food chain (Messner et al., 2020); food donation (Busetti, 2019); reducing the volume of a portion and, accordingly, its cost (Zhao & Manning, 2019); development of highly efficient technologies for production and deep processing of products, the introduction of algorithms for structuring logistics, storage and processing of food products and waste disposal, increasing the energy efficiency of production processes (Galstyan et al., 2019).

Conflict of interest

The authors declare no conflict of interest. Besides, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

References

Abbade, E. (2020). Estimating the nutritional loss and the feeding potential derived from food losses worldwide. *World Development*, 134. doi: 10.1016/j.worlddev.2020.105038.

Alfiero, S., Christofi, M., & Bonadonna, A. (2019). Street food traders, farmers and sustainable practice to reduce food waste in the Italian context. *British Food Journal*, 122(5), 1361–1380. doi: 10.1108/BFJ-04-2019-0265.

Amicarelli, V., Bux, C., & Lagioia, G. (2020). How to measure food loss and waste? A material flow analysis application. *British Food Journal*, 123 (1), 67-85. doi: 10.1108/BFJ-03-2020-0241.

Babych, M., & Kovalenko, A. (2018). Food Security Indicators in Ukraine: Current State and Trends of Development. *Baltic Journal of Economic Studies*,

4(1), 8-15. doi: 10.30525/2256-0742/2018-4-1-8-15

Babych, M. (2018, April 23). Losses of food and food waste on the basis of creating their value. *Economics, Marketing and Law: Theoretical Approaches and Practical Aspects of Development*. Oral presentation conducted at Tropentag 2018, Poltava, Ukraine. Retrieved from <http://www.economics.in.ua/2017/10/konference201709.html>

Bonadonna, A., Matozzo, A., Giachino, C., & Peira, G. (2019). Farmer behavior and perception regarding food waste and unsold food, *British Food Journal*, 121(1), 89-103. doi: 10.1108/BFJ-12-2017-0727

Busetti, S. (2019). A theory-based evaluation of food waste policy: Evidence from Italy. *Food policy*, 88. doi: 10.1016/j.foodpol.2019.101749

Cane, M. & Parra, C. (2020). Digital platforms: mapping the territory of new technologies to fight food waste. *British Food Journal*, 122(5), 1647–1669. doi: 10.1108/BFJ-06-2019-0391.

Dusoruth, V., & Peterson, H. (2020). Food waste tendencies: behavioral response to cosmetic deterioration of food. *PLOS ONE*, 15(5). doi: 10.1371/journal.pone.02332870.

FAO (2011). Global food losses and food waste – Extent, causes and prevention. Retrieved from <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf>

FAO (2020). What is food loss and food waste? Retrieved from <http://www.fao.org/food-loss-and-food-waste/flw-data>

Zhao, X., & Manning, L. (2019). Food plate waste: factors influencing insinuated intention in a university food service setting. *British Food Journal*, 121(7), 1536-1549. doi: 10.1108/BFJ-07-2018-0481

Galstyan, A., Aksyonova, L., Lisitsyn, A., Oganesyants, L., & Petrov, A. (2019). Modern Approaches to Storage and Effective Processing of Agricultural Products for Obtaining High Quality Food Products. *Herald of the Russian academy of sciences*, 89(2), 211-213. doi: 10.1134/S1019331619020059

- Goodman-Smith, F., Miroso, M., & Skeaff, S. (2020). A mixed-methods study of retail food waste in New Zealand. *Food Policy*, 92. doi: 10.1016/j.foodpol.2020.101845.
- Johnson, L., Dunning, R., Gunter, C., Bloom, J., Boyette, M., & Creamer, N. (2018). Field measurement in vegetable crops indicates need for reevaluation of on-farm food loss estimates in North America. *Agricultural systems*, 167, 136-142. doi: 10.1016/j.agry.2018.09.008
- Johnson, L., Bloom, J., Dunning, R., Gunter, C., Boyette, M., & Creamer, N. (2019). Farmer harvest decisions and vegetable loss in primary production. *Agricultural systems*, 176. doi: 10.1016/j.agry.2019.102672
- Kotykova, O. (2010). Grounding and realization of land resources management principles as a way to maintain stable development of land tenure. *Actual Problems of Economics*, 1, 75-79.
- Kotyková, O., & Babych, M. (2019a). Economic Impact of Food Loss and Waste. *AGRIS on-line Papers in Economics and Informatics*, 11(3), 57-71. doi: 10.7160/aol.2019.110306
- Kotykova, O., & Babych, M. (2019b). Limitations in availability of food in Ukraine as a result of loss and waste. *Oeconomia Copernicana*, 10(1), 153-172. doi: 10.24136/oc.2019.008
- Kotykova, O., Babych, M., & Krylova, I. (2020). Forming the system of food security indicators following the criteria of the SDGs-2030. *Potravinarstvo*, 14, 1055-1065. doi: 10.5219/1443
- Kotykova, O., Babych, M., & Yahodzinska, A. (2020). The system of the food security criteria in accordance with the measurements of the SDGs-2030. *Management Theory and Studies for Rural Business and Infrastructure Development*, 42(3), 399-408. doi: 10.15544/mts.2020.40
- Kotykova, O., Babych, M., & Pohorielova, O. (2020). Impact of economic affordability of food on the level of food consumption by Ukrainian households. *Intellectual Economics*, 14(1), 463-473. doi: 10.13165/IE-20-14-1-05
- Messner, R., Richards, C., & Johnson, H. (2020). The "Prevention Paradox": food waste prevention and the quandary of systemic surplus production. *Agriculture and Human Values*, 37, 805-817. doi: 10.1007/s10460-019-10014-7
- Pellegrini, G., Sillani, S., Gregori, M., & Spada, A. (2019). Household food waste reduction: Italian consumers' analysis for improving food management. *British Food Journal*, 121(6), 1382-1397. doi: 10.1108/BFJ-07-2018-0425.
- Popat, M., Griffith, G., Mounter, S., & Cacho, O. (2020). Postharvest losses at the farm level and its economy-wide costs: the case of the maize sector in Mozambique. *Agrekon*, 59(2), 235-253. doi: 10.1080/03031853.2020.1721305
- Rosenlund, J., Nyblom, A., Matschke Ekholm, H., & Sorme, L. (2020). The emergence of food waste as an issue in Swedish retail. *British Food Journal*, 122(11), 3283-3296. doi: 10.1108/BFJ-03-2020-0181.
- State Statistics Service of Ukraine. (2018). *Agriculture of Ukraine. Ukraine: Distribution of statistical publications of the State Statistics Service of Ukraine*. Retrieved from <http://www.ukrstat.gov.ua/>
- Worldbank. (1998). *Indicators of Land Quality and Sustainable Land Management*. Retrieved from <http://documents1.worldbank.org/curated/en/487661468739557843/pdf/multi-page.pdf>



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