ORIGINAL ARTICLE

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Limitations in availability of food in Ukraine as a result of loss and waste

Abstract

Research background: The commitment to increasing the volume of agricultural production remains the main strategy for food supply in Ukraine. In fact, such an approach does not solve the problem of the limitation of food's physical availability. It works quite the opposite way, as there is a guaranteed food loss and waste, worsened environmental situation and decreased level of economic availability of food.
Purpose of the article: According to the results of the empirical study, the volume of food shortages has been determined as a result of food loss and waste, food surpluses in case of compliance with the rational consumption norms and zero food loss and waste, as well as potential social benefits from reducing food loss and waste.
Methods: The research of the limitation of the physical availability of the different types of products as a result of food loss and waste was carried out according to the methodology developed by the authors. In particular, for the group of products in which the consumption deficit is established in a small number of regions — the main indicator is the "production surplus in the conditions when the rational consumption norms and zero food loss are met"; for the group of products in which the consumption deficit is established in the vast majority of regions — the main calculation indicators are the "production shortage in the conditions when the rational con-

sumption norms and zero food loss are met" and the "specific gravity of the consumption short-
age, which occurs as a result of food loss and waste".
Findings & Value added: The obtained results are crucially important for shaping of the food
security policy. Reducing of the food loss and waste has positive social consequences through the
expansion of the physical availability of food, which, under other conditions, leads to greater
economic availability of products, as well as contributes to the gender equality and poverty reduc-
tion for rural residents.

Introduction

The calculation of the food loss and waste scale in Ukraine has showed that
approximately one in every ten calories made for human consumption is
ultimately not consumed by them (Babych, 2018). Food is being lost in
various ways in all regions of Ukraine, at all stages of the creation of chain
of food value, and in all types of products. As a result, the physical and
economic availability of food is decreasing, and the burden on the agrarian
sector is increasing: more and more food is required to compensate for the
loss of food that is ultimately not consumed by humans.

The main potential social benefits from the reduction of food loss and
waste in Ukraine are shown in Figure 1.

The purpose of this study is to empirically investigate the size of food
shortages as a result of food loss and waste, food surplus if it meets the
rational consumption standards and zero food loss and waste, as well as
identify potential social benefits from the reduction of food loss and waste.

The object of the study is the limitation of the physical availability of
food products as a result of food loss and waste. The research subject in-
cludes the indicators of the deficit and the surplus of the different types of
products in the regions of Ukraine due to the food loss and waste and their
reduction.

"Literature Review" section provides a brief description of the works of
researchers who are investigating the problem of food loss and waste at the
national level and in the global scale. Then, "Research methodology" in-
forms on principles, data base, methodology and sequence of calculations
of indicators for assessing the limitation of physical availability of food
products as a result of food loss and waste. The "Results" section presents
the calculated indicators of consumption deficit and food surplus under
compliance to rational consumption norms and with zero food losses across
the regions of Ukraine and among the main kinds of products. Then, "Dis-
cussion" section comments the author's contribution to solving the re-
searched problem. Finally, "Conclusions" section defines the limitations on
the possibility of achieving zero losses and outlines issues that require re-
search in the future.

Literature review

The problem of food loss and waste is extensively investigated by foreign scientists, in particular, in the EU and the US. Among the most important studies that cover the national and global levels of the problem, the following works should be highlighted.

Lipinski *et al.* (2013) have carried out research on the estimation of food loss and waste globally (according to 2009), defined the terms "loss of food" and "food loss and waste", and also proposed the strategies aimed at reduction of food losses. About 24 percent of all calories currently produced for human consumption are lost or wasted. This paper examines the implications of this amount of loss and waste, profiles a number of approaches to reducing it, and puts forward five recommendations on how to move forward with this issue. "Reducing Food Loss and Waste" is the second installment in the series that forms the foundation of the "World Resources Report 2013–14: Creating a Sustainable Food Future".

The FAO study (2011) highlights the losses that occur along the entire food chain, and measures their magnitude; the causes of food losses and possible ways of their prevention are determined.

The work of the SAVE FOOD (2015) is devoted to the issues of "food loss" and "food waste" terminology, the conditions for the emergence and consequences of food and food waste loss, as well as strategies for reducing the loss of food and food waste in a globalized world.

The FAO study (2013) provides a global assessment of the environmental impacts of food loss and waste on each stage of the food chain, focusing on climate, water, land and biodiversity impacts, as well as economic quantification, which is based on the world prices of producers. The paper answers two main questions: what are the consequences of a loss of nutrition for natural resources and where are these consequences coming from? As a result, researchers identify "hot spots of the environment" and thus determine the directions and measures to reduce their impact.

Hanson (2017) presents the results of the interviews with the government and business leaders, which identified a set of the strategic but nonfinancial motivators to reduce food and waste related to food security, waste management, environmental sustainability, relations with stakeholders and ethical responsibility. As a result of the study, the authors propose a business criterion for the reduction of food losses and waste for the public and private sectors, built on the principle: goal-meta-action.

Schuster and Torero (2016) have explored issues of terminology and methodology for measuring food loss and waste, and developing effective food-chain policy solutions: international organizations and research insti-

tutes, national and local governments, civil society and retailers. The authors have investigated a range of postharvest loss estimates by commodity from various studies in Africa, case studies of food loss — Kenya and Nigeria, and losses in the Nigerian cassava value chain.

Chegere (2018) has shown that reducing post-harvest losses is a key component for the complementation of efforts to address food safety issues and for the increasing of incomes of the agricultural enterprises, especially for the low-income households. The research analyzes the role of recommended crop treatment methods (with the aim of losses' reduction) and estimates the losses and benefits associated with the practice of reducing food loss during storage.

Tesfaye and Tirivayi (2018) analyze the impact of improved storage technologies on the safety and well-being of food products through national representative data from Ethiopia. The study has found that the use of advanced food storage technologies increases dietary diversity and reduces child malnutrition. Overall, research shows that improved storage technologies can improve food and nutrition security and play a key role in the mitigation of nutrition problems of a growing population.

Richards and Hamilton (2018) have explored the potential for commercial peer-to-peer network (CPMS) or joint-venture firms to enter the market as exchange platforms. Their findings suggest that the secondary markets have the key elements needed to succeed CPMS and the policy tools aimed at facilitating transactions in the secondary markets can be very effective in reduction of food loss and waste.

Mylona (2018) provided the study of the possible effects of the global trends, such as climate change and the lack of resources for the food security. The document builds on the results of the 2050 food safety and food research in the EU.

Zezza (2017) presents the results of the international multidisciplinary research project on measuring of the food intake in the national household surveys. The case studies of developing countries and OECD countries are synthesized in this paper.

Sheahan and Barrett (2017) explore the contemporary approaches to the mitigation of the effects of food loss and waste during the storage phase in Africa. This article reviews the current state of the literature on PHL mitigation. First, they identify explicitly the varied objectives underlying the efforts to reduce PHL levels. They summarize the estimated magnitudes of losses, evaluate the methodologies used to generate those estimates, and explore the dearth of thoughtful assessment around "optimal" PHL levels. Then, they synthesize and critique the impact evaluation literature around on-farm and off-farm interventions expected to deliver PHL reduction.

Finally, they suggest a suite of other approaches to advancing these same objectives, some of which may prove more cost-effective.

Summarizing the results of the scientifical research, it is quite obvious that the potential benefits of the reduction of food loss and waste are concentrated in three areas: environmental (rational use of resources to reduce anthropogenic pressure on the environment), social (increased food availability, poverty eradication and gender inequality, especially in rural areas) and economic (preventing economic losses, saving money and resources) in a case of maintaining of the sufficient level of food security.

Our research focuses on social aspects. The hypothesis of the study is the assumption that food loss and waste limit the food physical availability, while reduction of food loss and waste has significant potential social benefits.

Research methodology

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. It is not feasible to calculate over a longer period as according to previous studies (Babych & Kovalenko, 2018), the level of production and consumption of food per capita in Ukraine over the past 5 years has practically not changed.

The research of the limitation of the physical availability of the different types of products as a result of food loss and waste was carried out according to the methodology developed by the authors. The authors' methodological is based on the following principles:

1. principle of purpose – assessment of the impact of food and food waste on the level of on the physical availability of food products;
2. the principle of time-unity (Kotykova, 2010) and certain system of indicators;
3. the systemic principle – systematization of indicators for species of products and regions;
4. the scientific principle – the use of different types of empirical research;
5. the principle of maximum informativeness, including visual perception.

The study of the limitation of physical availability of different types of products as a result of food loss and waste was carried out according to the method developed by the authors. In accordance with the purpose of the study and the above principles, an appropriate system of indicators is proposed. In particular, for the group of products in which the consumption deficit is established in a small number of regions — cereals, vegetables and potatoes — the main indicator is the "production surplus in the condi-

tions when the rational consumption norms and zero food losses are met" (EP_i); for the group of products in which the consumption deficit is established in a vast majority of regions — milk, meat, fruits and vegetables — the main calculation indicators are the "production shortage in the conditions when the rational consumption norms and zero food losses are met" (SP_i) and the "specific gravity of the consumption shortage, which occurs as a result of food loss and waste". The calculation of the deficit and the surplus of production, in case of compliance with the rational consumption norms and zero food losses are carried out by the Formulas 1 and 2:

$$CD_i + FLW_i = SP_i, \tag{1}$$

$$if \ (CD_i + FLW_i) < 0$$

$$CD_i + FLW_i = EP_i, \tag{2}$$

$$if \ (CD_i + FLW_i) > 0$$

where SP_i are the deficit of the food production in case of compliance with the rational consumption norms and zero food losses, kg per capita; EP_i is the surplus of the food production in case of compliance with the rational consumption norms and zero food losses, kg per capita; CD_i is the consumption shortage, kg per capita / kcal; FLW_i is the food loss and waste, kg per capita / kcal.

If as a result of calculations we get a negative value of the indicator — we have a shortage, if positive — we have a surplus.

$$CD_i = AC_i - RC_i, \tag{3}$$

where AC_i is an actual consumption per capita, kg; RC_i is the rational consumption rate per capita, kg.

$$FLW_i = \frac{FLW_{gen}}{P}, \tag{4}$$

where FLW_{gen} is the total food loss and waste, kg; P is population, persons.

The methodology proposed by FAO (Figure 2) is used to calculate the total food loss and waste (FLW_{gen}) in Ukraine.

The calculated weight percentages of food loss and waste are used (as a percentage of what is included at each stage) (Table 1).

FAO's assessment is weight-based. When considering a ton of grain, its

weight is the same as that of a ton of fruits or a ton of meat. However, these types of food vary greatly in terms of calories per kilogram. For example, a kilogram of potatoes contains, on average, 767 kcal, while a kilogram of meat contains 1434 kcal. Consequently, the weight measurement does not always reflect the foods' energetic nutrition that can be consumed by people. For this very reason the calculations of food loss and waste of animal origin products, were also conducted, showing significant consumption deficit, in kcal.

Results

Food loss and waste leads to the limitation of the physical availability of food. The results of our calculations of the possible volumes of the food shortages coverage in case of compliance with the rational consumption norms and zero food losses for different types of products are the confirmation of this thesis.

Thus, there is no shortage of bread products' consumption in Ukraine as a whole, but in Dnipropetrovsk, Zaporizhzhia, Kyiv, Luhansk, Lviv, Rivne and Kharkiv regions it is from 1.5 to 18.9 kg per capita (Table 2).

Food loss and waste per capita in Ukraine make up 64.3 kg of bread products, which is higher than the rational consumption rate (101 kg) in Vinnytsa, Zhytomyr, Zaporizhzhia, Kyiv, Kirovograd, Poltava, Sumy, Khmelnytskiy and Cherkasy regions; the smallest — in the Chernivtsi region. Thus, the ratio between the smallest and the largest food losses is 1:58. In all regions, food loss and waste exceeds the deficit, so in areas where there was a shortage of products at zero food losses, a positive balance and even surplus of grain products will be established: Dnipropetrovsk — 5.5 kg / person, Zaporizhzhia — 36.6 kg / person, Kyiv — 90.9 kg / person, Luhansk — 1.1 kg / person, Lviv — 26.7 kg / person, Rivne — 24.7 kg / person, Kharkiv — 29.3 kg / person. Due to the insurance fund, which is 20% of the rational consumption norm, there will be deficit of bread products in all regions of Ukraine, and with zero food losses, it will remain only in Dnipropetrovsk, Luhansk and Chernivetsi regions.

Concerning potatoes, there is also no shortage of consumption in Ukraine as a whole, at the same time it was from 3.8 to 25.8 kg per capita in Dnipropetrovsk, Donetsk, Zaporizhzhia, Luhansk, Mykolayiv, Odesa and Kharkiv regions. Food and food waste per capita in Ukraine make up 117.1 kg of potatoes, which is higher than the rational consumption rate (124 kg) in Vinnytsa, Volyn, Zhytomyr, Ivano-Frankivsk, Kyiv, Kirovograd, Rivne, Sumy, Ternopil, Khmelnytskiy, Cherkasy, Chernivtsi and

Chernihiv regions; the smallest — in the Donetsk region. Thus, the ratio between the smallest and the largest losses of food is 1:8. In all regions, food loss and waste exceeds the deficit, so in areas where there was a shortage of products with zero food losses, a positive balance and even a surplus of potatoes will be established: in Dnipropetrovsk — 51.9 kg / person, Donetsk — 10.6 kg / person, Zaporizhzhia — 30.6 kg / person, Luhansk — 30.5 kg / person, Mykolayiv — 64.7 kg / person, Odesa — 44.7 kg / person, Kharkiv — 86.2 kg / person. Taking into account the insurance fund, which is 20% of rational consumption norm, there will be shortage of potatoes in the Zakarpattia, Kyiv, Kirovograd, Poltava and Kherson regions of Ukraine, and with zero food losses it will remain only in Donetsk region.

There is no shortage of consumption of vegetables in Ukraine as a whole, however, it was from 1.2 to 43.4 kg per capita in Volyn, Donetsk, Ivano-Frankivsk, Luhansk, Lviv, Rivne and Khmelnytskiy regoins. Food loss and waste per capita in Ukraine make up 79.6 kg of vegetables, which is higher than the rational consumption rate (161 kg) in Kherson region; the smallest loss (33.6 kg) — in the Luhansk region. Thus, the ratio between the smallest and the largest food losses is 1:11. In all regions, food loss and waste exceeds the deficit, thus, in areas where there was a shortage of products in case of zero food losses a positive balance will be established, and even an excess of vegetables: in Volyn — 73.6 kg / person, Donetsk — 25.2 kg / person Ivano-Frankivsk — 24.1 kg / person, Lviv — 65.5 kg / person, Rivne — 38.4 kg / person, Khmelnytskiy — 33.5 kg / person. The exception is the Luhansk region, where even with zero food losses a negative balance of 9.8 kg per capita will be established. Taking into account the insurance fund, which is 20% of the rational norm of consumption, there will be deficit of vegetables in all regions of Ukraine, and in case of zero loss of food it will survive only in Donetsk and Ivano-Frankivsk regions.

The consumption of fruits and vegetables per capita in Ukraine does not meet the norm: the average deficit in the country is 40.3 kg; in terms of the regions the highest level is set in Luhansk (54.4 kg), and the smallest one — in Kyiv region (16.9 kg). Thus, the ratio between the smallest and the largest shortage is 1:3 (Table 3).

In Volyn, Donetsk, Kirovograd, Luhansk, Rivne, Sumy, Ternopil, Kherson, Khmelnytskiy and Chernihiv regions, the deficit in fruit and vegetable consumption exceeds a half of the rational norm of consumption (45 kg per capita).

In five regions of Ukraine (Vinnytsa, Kyiv, Poltava, Khmelnytskiy and Chernivtsi) the loss of fruits is more than 45 kg per capita, and in only three

regions (Luhansk, Sumy and Chernihiv regions) is less than 10 kg per capita. Thus, in Vinnytsa, Kyiv, Poltava, Khmelnytskiy and Chernivtsy regions the share of the food consumption shortage due to the food loss and waste is 100%, and hence the deficit of fruit consumption in a case of compliance with the rational consumption norms and zero food losses in these regions will be overcome. The deficit index will remain high in Donetsk, Luhansk and Sumy regions (over 40 kg per capita). In another four regions (in Dnipropetrovsk, Zakarpattia, Mykolayiv and Kherson regions), the share of consumption deficits due to the food loss and waste exceeds 50%.

The consumption of meat and meat products per capita in Ukraine does not meet the norm: the average deficit in the country is 28.6 kg; in terms of the regions, the highest level is set in Luhansk (40.4 kg), and the smallest one — in Kyiv region (17.5 kg). Thus, the ratio between the smallest and the highest deficit is 1:2.3.

The deficit of meat and meat products consumption in Vinnytsa, Volyn, Zhytomyr, Zakarpattia, Zaporizhzhia, Ivano-Frankivsk, Luhansk, Lviv, Mykolayiv, Odesa, Poltava, Rivne, Sumy, Ternopil, Kharkiv, Kherson, Khmelnytskiy, Cherkasy, Chernivtsi and Chernihiv regions exceeds one third of the rational norm of their consumption (80 kg per capita).

In five regions of Ukraine (Vinnytsa, Volyn, Dnipropetrovsk, Kyiv and Cherkasy) the loss of meat and meat products is more than 27 kg per capita and in Luhansk region is less than 10 kg per capita. Thus, in Vinnytsa, Volyn, Dnipropetrovsk, Kyiv and Cherkasy regions the share of food consumption shortage due to the food loss and waste is 100%, and hence the deficit of fruit consumption in case of compliance with the rational consumption norms and zero food losses in these regions will be overcome. The deficit ratio will remain high enough in Zakarpattia, Ivano-Frankivsk, Luhansk, Mykolayiv, Odesa and Chernivtsi regions (more than 20 kg per capita). In Donetsk, Kirovograd, Lviv, Poltava, Ternopil, Kharkiv, Kherson and Khmelnytskiy the share of consumption deficits due to the food loss and waste exceeds 50%.

The consumption of milk and dairy products per capita in Ukraine does not meet the norm: the average deficit in the country is 170.5 kg; In terms of the regions, the highest level is set in Luhansk (241.8 kg), and the smallest one — in Ivano-Frankivsk region (98.6 kg). Thus, the ratio between the smallest and the highest deficit is 1:2.5.

In Donetsk, Zaporizhzhia and Odesa regions, the deficit of milk and dairy products exceeds 50% of the rationale norm of consumption (190 kg per capita); in the rest (except of Ivano-Frankivsk region) — 30% of rational consumption (127 kg per capita).

The loss of milk and dairy products in nine regions of Ukraine (Vinnytsa, Zhytomyr, Kyiv, Poltava, Sumy, Ternopil, Khmelnytskiy, Cherkasy and Chernihiv) is more than 50 kg per capita, and only in Donetsk and Luhansk regions is less than 20 kg per capita. The share of consumption deficits due to the food loss and waste is below 50%, and hence the deficit of milk and dairy products consumption in a case of compliance with the rational consumption norms and zero food losses in these regions will not be overcome. In case of compliance with the rational consumption norms and zero food losses the highest level of deficit is in Donetsk, Zaporizhzhia, Luhansk and Odesa regions (over 150 kg per capita). In Donetsk and Luhansk regions the share of consumption deficits due to the food loss and waste does not exceed 10%.

In general, the consumption of animal products in Ukraine is 790 kcal per day, which is in 585 kcal less than the rational norm of consumption (Table 4). The highest level of shortage in animal products consumption (more than 600 kcal per capita) was established in Zhytomyr, Ivano-Frankivsk, Kirovograd, Lvivska, Sumy and Kherson regions, and the smallest one (484 kcal per capita) in Chernivtsi region.

At the same time, the share of food consumption shortage due to the food loss and waste in Vinnytsa, Kyiv and Cherkasy regions is more than 50% and less than 10% in Luhansk region. In absolute terms, the loss of food loss and waste per capita is from 54 kcal in the Luhansk region to 334 kcal in Cherkasy region (1:6), in particular: up to 100 kcal — in Donetsk, Zakarpattia, Zaporizhzhia, Luhansk and Mykolayiv regions; from 101 to 199 kcal — in Volyn, Dnipropetrovsk, Zhytomyr, Ivano-Frankivsk, Kirovograd, Lviv, Poltava, Rivne, Sumy, Ternopil, Kharkiv, Kherson, Khmelnytskiy, Chernivtsi and Chernihiv regions; from 200 to 299 kcal — in Kyiv region; 300 and more kcal — in Vinnytsa and Cherkasy regions.

Discussion

Domestic scientists devote inadequate attention to this problem: Ukraine does not have full-scale studies of food loss and waste at the regional or national level. Undoubtedly, there are scholarly works dealing with certain aspects of the problem under the study, but they are local and unsystematic.

The overwhelming majority of scientific works, in which the issue of food and food waste is being studied in one way or another, belongs 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 is classified as "Europe". It is quite obvious that the averaged

indicators of this group are not close to the realities of Ukraine, and there-
fore — proposals for reducing food loss and waste, developed on the basis
of such analytical data, cannot be fully representative for our country,
which required the corresponding calculations according to actual data. For
this reason, the authors carried out respective calculations of food loss and
waste in Ukraine. The calculations were conducted according to the type of
main products and regions (Babych, 2018), which our research of the
physical availability of food products are grounding on.

There is no study of the impact of food loss and waste on the level of
food physical avalability's limitation in Ukraine at all. From this point of
view, this scientific research has an important theoretical and practical
significance: a new methodological approach has been developed; and the
hypothesis that food loss and waste limit physical availability of food and
the reduction of losses has a significant potential social benefit is
confirmed.

The obtained results are of the utmost importance in shaping the food
supply policy in Ukraine. Firstly, it has been empirically proven that the
zero losses of food loss and waste on grains, potatoes and vegetables make
it possible to form the food insurance fund for these products, but for meat
and meat products, milk, dairy products, and fruits — to provide up to 50%
coverage of the existing shortage of consumption of these products. At the
same time, it is not necessary to spend additional resources, which creates
an excessive pressure on the environment and leads to the greater environ-
mental and economic losses. Secondly, reducing the food loss and waste
has positive social consequences through the expansion of the physical
availability of food, which, under other conditions, leads to greater eco-
nomic availability of products, as well as contributes to the gender equality
and poverty reduction for rural residents.

Conclusions

It is proved that food loss and waste has significant negative social conse-
quences. The social consequences of food loss and waste constitute
a limitation on access to food. According to the calculations on bread prod-
ucts, potatoes and vegetables, there is no deficit of consumption in Ukraine
as a whole. At the same time, taking into account the insurance fund, there
will be shortage of these products in the vast majority of regions of
Ukraine. The consumption of fruits and vegetables, meat and meat prod-
ucts, milk in Ukraine per capita is not in line with the norm: the average
deficit in the country is 40.3, 27.6 and 170.5 kg, respectively. At the same

time, the share of food consumption and food loss and waste accounted as 61.6% for fruits and vegetables, 72.0% for meat and meat products, and 25.4% for milk.

It is established that at zero losses of food, food shortage will continue only in several regions of Ukraine for certain types of products. Such indicators (zero losses of food) correspond to the level of technology of the developed countries, but are not yet available to Ukraine: the degree of wear of fixed assets in agriculture, forestry and fisheries makes up 37.3% in 2016 (State Statistics Service of Ukraine, 2016); 57.7% of livestock production in 2016 was produced by households without special equipment for mechanized milking, special refrigerated milk storage cells and specialized slaughter equipment. On the other hand, Ukraine has developed and adopted relevant laws that require compliance with the European norms in the production of milk and meat, including mechanized milking and special areas for slaughter of animals, which significantly reduces the rates of food and food waste at this stage and they will indeed correspond to the FAO.

The reduction of food loss and waste can be one of those rare strategies that will have the highest effect with minimal cost.

In our opinion, these studies — the clarification of weight percentages of food loss and waste for Ukraine — should be carried out in the future.

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Acknowledgments

Annex

Table 1. Weight percentages of food loss and waste (as a percentage of what is included at each stage) for Europe

Type of production	Agricultural Production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket Retail	Consumption
Cereals	2	4	0.5-10	2	25
Roots and tubers	20	9	15	7	17
Oilseeds and pulses	10	1	5	1	4
Fruits and vegetables	20	5	2	10	19
Meat	3.1	0.7	5	4	11
Fish and seafood	9.4	0.5	6	9	11
Milk	3.5	0.5	1.2	0.5	7

Scource: FAO (2011, p. 33–35).

Table 2. Limitations of the physical availability of grain products, potatoes and vegetables as a result of food loss and waste in Ukraine in 2016

Region	Actual consumption per capita per year, kg AC_i			Deficit (-) in consumption, kg per capita CD_i			Food loss and waste per capita, kg FLW_i			Surplus (+) of products in a case of compliance with the rational consumption norms and zero food losses, kg EP_i		
	grain	potato	vegetables	grain	potato	vegetables	grain	potato	vegetables	grain	potato	vegetables
Ukraine	101.0	139.8	163.7	0.0	15.8	2.7	64.3	117.1	79.6	64.3	132.9	82.3
Vinnytsa	111.3	184.4	176.0	10.3	60.4	15.0	190.5	236.3	93.1	200.8	296.7	108.1
Volyn	108.4	183.0	155.5	7.4	59.0	-5.5	47.4	181.2	79.1	54.8	240.2	73.6
Dnipropetrovsk	94.8	119.4	185.7	-6.2	-4.6	24.7	11.7	56.5	69.1	5.5	51.9	93.8
Donetsk	105.6	98.2	147.4	4.6	-25.8	-13.6	11.0	36.4	38.8	15.6	10.6	25.2
Zhytomyr	110.1	184.6	165.8	9.1	60.6	4.8	107.9	230.1	73.8	117.0	290.7	78.6
Zakarpattia	111.6	143.6	162.0	10.6	19.6	1.0	12.4	83.3	65.0	23.0	102.9	66.0
Zaporizhzhia	96.2	107.2	167.7	-4.8	-16.8	6.7	41.4	47.4	78.2	36.6	30.6	84.9
Ivano-Frankivsk	111.3	189.6	138.4	10.3	65.6	-22.6	25.9	140.4	46.7	36.2	206.0	24.1
Kyiv	82.1	127.0	170.9	-18.9	3.0	9.9	109.8	291.3	149.7	90.9	294.3	159.6
Kirovograd	105.6	148.7	176.5	4.6	24.7	15.5	210.7	163.3	77.7	215.3	188.0	93.2
Luhansk	87.5	109.0	117.6	-13.5	-15.0	-43.4	14.6	45.5	33.6	1.1	30.5	-9.8
Lviv	99.5	181.0	159.8	-1.5	57.0	-1.2	28.2	118.2	66.7	26.7	175.2	65.5

Table 2. Continued

Region	Actual consumption per capita per year, kg AC_i			Deficit (-) in consumption, kg per capita CD_i			Food loss and waste per capita, kg FLW_i			Surplus (+) of products in a case of compliance with the rational consumption norms and zero food losses, kg EP_i		
	grain	potato	vegetables	grain	potato	vegetables	grain	potato	vegetables	grain	potato	vegetables
Mykolayiv	109.2	116.4	187.2	8.2	-7.6	26.2	51.7	69.3	141.8	59.9	61.7	168.0
Odesa	103.5	111.0	161.1	2.5	-13.0	0.1	43.5	57.7	59.4	46.0	44.7	59.5
Poltava	103.2	146.3	188.5	2.2	22.3	27.5	237.9	122.0	105.7	240.1	144.3	133.2
Rivne	94.9	170.4	137.2	-6.1	46.4	-23.8	30.8	184.0	62.2	24.7	230.4	38.4
Sumy	104.4	174.0	164.3	3.4	50.0	3.3	200.7	205.7	57.2	204.1	255.7	60.5
Ternopil	101.4	157.3	161.2	0.4	33.3	0.2	80.8	166.5	73.6	81.2	199.8	73.8
Kharkiv	94.5	120.2	179.2	-6.5	-3.8	18.2	35.8	90.0	78.3	29.3	86.2	96.5
Kherson	112.7	145.8	171.2	11.7	21.8	10.2	39.7	71.3	369.4	51.4	93.1	379.6
Khmelnytskiy	112.0	174.2	139.7	11.0	50.2	-21.3	147.5	182.8	54.8	158.5	233.0	33.5
Cherkasy	118.8	159.6	175.3	17.8	35.6	14.3	165.1	145.0	86.3	182.9	180.6	100.6
Chernivtsi	108.4	154.9	178.4	7.4	30.9	17.4	4.1	136.5	83.9	11.5	167.4	101.3
Chernihiv	109.1	167.0	171.5	8.1	43.0	10.5	84.2	145.5	60.6	92.3	188.5	71.1

Table 3. Limitations of the physical availability of fruits and vegetables, meat and meat products, milk and dairy products as a result of food loss and waste in Ukraine in 2016

Region	Actual consumption per capita per year, kg AC_i			Consumption deficit per capita per year, kg CD_i			Food loss and waste per capita, kg FLW_i			Deficit (-) of products, in a case of compliance with the rational consumption norms and zero food losses, kg SP_i			Specific gravity of the food consumption deficit, which occurs as a result of food loss and waste, %		
	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products
Ukraine	49.7	51.4	209.5	-40.3	-28.6	-170.5	24.8	20.6	43.3	-15.5	-8.0	-127.2	61.6	72.0	25.4
Vinnytsa	54.6	52.6	205.0	-35.4	-27.4	-175.0	55.8	53.9	75.9	20.4	26.5	-99.1	100.0	100.0	43.4
Volyn	40.4	50.4	210.0	-49.6	-29.6	-170.0	16.6	30.3	46.6	-33.0	0.7	-123.4	33.5	100.0	27.4
Dnipropetrovsk	59.1	61.9	204.6	-30.9	-18.1	-175.4	19.5	27.1	27.1	-11.4	9.0	-148.3	63.0	100.0	15.5
Donetsk	37.7	54.3	169.3	-52.3	-25.7	-210.7	10.1	13.7	19.0	-42.2	-12.0	-191.7	19.3	53.4	9.0
Zhytomyr	46.6	48.9	218.8	-43.4	-31.1	-161.2	14.5	13.2	60.0	-28.9	-17.9	-101.2	33.4	42.5	37.2
Zakarpattia	50.0	47.6	229.1	-40.0	-32.4	-150.9	37.7	12.3	31.8	-2.3	-20.1	-119.1	94.1	38.0	21.1
Zaporizhzhia	46.1	51.0	181.9	-43.9	-29.0	-198.1	18.0	14.4	29.8	-25.9	-14.6	-168.3	41.0	49.8	15.0
Ivano-Frankivsk	46.2	42.6	281.4	-43.8	-37.4	-98.6	16.3	16.7	43.7	-27.5	-20.7	-54.9	37.2	44.6	44.3
Kyiv	73.1	62.5	221.7	-16.9	-17.5	-158.3	55.2	53.0	76.5	38.3	35.5	-81.8	100.0	100.0	48.3
Kirovograd	41.9	53.1	202.8	-48.1	-26.9	-177.2	16.0	16.8	47.3	-32.1	-10.1	-129.9	33.4	62.4	26.7
Luhansk	34.6	39.6	138.2	-55.4	-40.4	-241.8	9.5	8.3	17.9	-45.9	-32.1	-223.9	17.1	20.6	7.4
Lviv	46.2	48.8	232.7	-43.8	-31.2	-147.3	17.0	18.0	33.9	-26.8	-13.2	-113.4	38.9	57.8	23.0
Mykolayiv	47.6	46.6	212.6	-42.4	-33.4	-167.4	32.0	11.0	48.4	-10.4	-22.4	-119.0	75.5	33.1	28.9
Odesa	55.0	47.2	188.0	-35.0	-32.8	-192.0	47.6	10.5	27.7	12.6	-22.3	-164.3	100.0	32.1	14.4
Poltava	48.0	50.7	217.9	-42.0	-29.3	-162.1	19.8	19.4	81.0	-22.2	-9.9	-81.1	47.2	66.3	50.0

Table 3. Continued

Region	Actual consumption per capita per year, kg AC_i			Consumption deficit per capita per year, kg CD_i			Food loss and waste per capita, kg FLW_i			Deficit (-) of products, in a case of compliance with the rational consumption norms and zero food losses, kg SP_i			Specific gravity of the food consumption deficit, which occurs as a result of food loss and waste, %		
	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products	fruits	meat and meat products	milk and dairy products
Rivne	38.0	48.3	203.5	-52.0	-31.7	-176.5	19.6	15.1	45.3	-32.4	-16.6	-131.2	37.7	47.5	25.7
Sumy	36.3	47.3	194.8	-53.7	-32.7	-185.2	9.6	13.8	56.8	-44.1	-18.9	-128.4	17.9	42.1	30.7
Ternopil	42.0	46.6	245.7	-48.0	-33.4	-134.3	24.4	17.4	56.6	-23.6	-16.0	-77.7	50.7	52.0	42.2
Kharkiv	52.1	51.2	239.9	-37.9	-28.8	-140.1	18.3	14.7	42.4	-19.6	-14.1	-97.7	48.4	51.2	30.2
Kherson	44.9	52.6	213.3	-45.1	-27.4	-166.7	33.2	14.5	44.3	-11.9	-12.9	-122.4	73.5	52.9	26.6
Khmelnytskiy	55.7	48.9	225.1	-34.3	-31.1	-154.9	47.1	16.5	60.1	12.8	-14.6	-94.8	100.0	53.0	38.8
Cherkasy	47.8	50.5	221.1	-42.2	-29.5	-158.9	20.3	65.1	67.6	-21.9	35.6	-91.3	48.1	100.0	42.5
Chernivtsi	60.1	44.3	251.0	-29.9	-35.7	-129.0	67.2	15.0	40.6	37.3	-20.7	-88.4	100.0	41.9	31.5
Chernihiv	38.9	46.3	226.7	-51.1	-33.7	-153.3	9.3	14.4	73.9	-41.8	-19.3	-79.4	18.2	42.8	48.2

Note: the rationale norm for the consumption of fruits and vegetables is 90.0 kg, meat – 80.0 kg, milk – 380.0 kg.

Table 4. Limitations of the physical availability of animal products as a result of food loss and waste in Ukraine in 2016

Region	Caloric content of the daily diet, kcal		Consumption shortage, kcal per capita CD_i	Food loss and waste per capita, kcal per day FLW_i	Specific gravity of the food consumption deficit, which occurs as a result of food loss and waste, %
	Actual	According to the rational norms			
Ukraine	790	1375	585	131	22.4
Vinnytsa	790	1375	585	300	51.2
Volyn	857	1375	518	173	33.4
Dnipropetrovsk	825	1375	550	138	25.1
Donetsk	798	1375	577	76	13.2
Zhytomyr	750	1375	625	121	19.4
Zakarpattia	843	1375	532	85	16.0
Zaporizhzhia	819	1375	556	91	16.4
Ivano-Frankivsk	755	1375	620	116	18.7
Kyiv	844	1375	531	297	55.9
Kirovograd	767	1375	608	121	19.9
Luhansk	816	1375	559	54	9.6
Lviv	645	1375	730	110	15.1
Mykolayiv	811	1375	564	100	17.6
Odesa	803	1375	572	73	12.8
Poltava	785	1375	590	170	28.8
Rivne	798	1375	577	112	19.4
Sumy	754	1375	621	120	19.3
Ternopil	790	1375	585	134	22.9
Kharkiv	791	1375	584	107	18.3
Kherson	767	1375	608	108	17.8
Khmelnytskiy	836	1375	539	134	24.9
Cherkasy	836	1375	539	334	62.0
Chernivtsi	891	1375	484	106	21.9
Chernihiv	836	1375	539	142	26.4

Figure 1. Potential social benefits from the reduction of food loss and waste in Ukraine
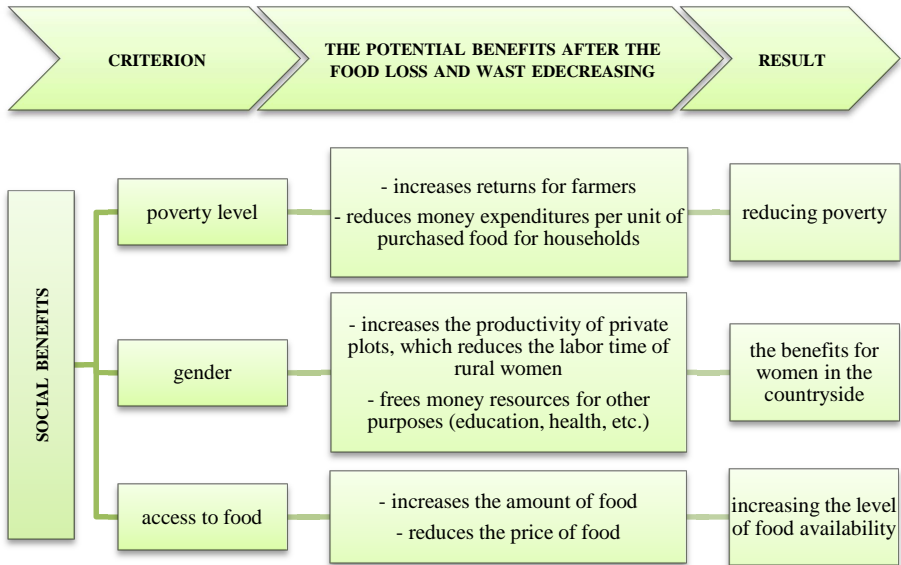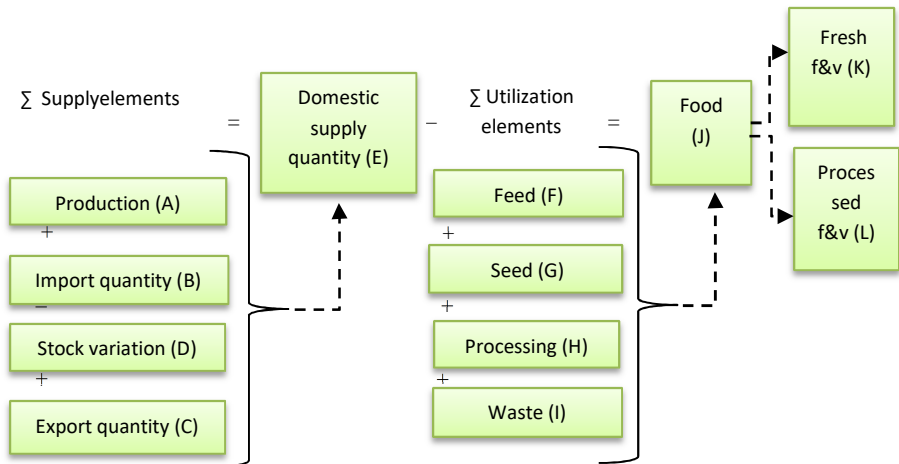
CRITERION	**THE POTENTIAL BENEFITS AFTER THE FOOD LOSS AND WAST EDECREASING**	**RESULT**

SOCIAL BENEFITS

poverty level	- increases returns for farmers - reduces money expenditures per unit of purchased food for households	reducing poverty
gender	- increases the productivity of private plots, which reduces the labor time of rural women - frees money resources for other purposes (education, health, etc.)	the benefits for women in the countryside
access to food	- increases the amount of food - reduces the price of food	increasing the level of food availability

Figure 2. The method of food loss and waste calculation

∑ Supplyelements = Domestic supply quantity (E) − ∑ Utilization elements = Food (J)

Production (A)
+
Import quantity (B)
−
Stock variation (D)
+
Export quantity (C)

Feed (F)
+
Seed (G)
+
Processing (H)
+
Waste (I)

Fresh f&v (K)

Procesed f&v (L)

A+B+C-D=E-(F+G+H+I)=J=K+L

Example: Calculations on losses and waste of milk in Ukraine. The below shows the mass flow of total milk (thousand tons) in the 2016.

Waste percentage in each step of the FSC:
Agricultural production = 3.5%
Postharvest handling and storage = 0.5%
Processing and packaging = 1.2%
Distribution (fresh & processed) = 0.5%
Consumption (fresh & processed) = 7%
Calculations on primary equivalent milk losses and waste in each step of the FSC:
Agricultural production: (0.035/(1-0.035))*10382 = 376.5 thousand tons
Postharvest handling and storage: 0.005*10382 = 51.9 thousand tons
Processing and packaging = 0.012*(2850+6090) = 107.3 thousand tons
Distribution (fresh): 0.005*58 = 0.3 thousand tons
Distribution (processed): 0.005*(2850+6090-107.7) = 44.2 thousand tons
Consumption (fresh): 0.07*(58-0.3) = 4.0 thousand tons
Consumption (processed): 0.07*(2850+6090-107.3-44.2) = 615.2 thousand tons
Conversion factors:
peeling by hand = 1.0;
industrial peeling = 1.0;
mean = 0.1
Calculations on edible milk losses and waste in each step of the FSC:
Agricultural production: 376.5*1.0 = 376.5 thousand tons
Postharvest handling and storage: 51.9*1.0 = 51.9 thousand tons
Processing and packaging: 107.3*1.0 = 107.3 thousand tons
Distribution: (0.3*1.0)+(44.2*1.0) = 44.5 thousand tons
Consumption: (4.0*1.0)+(615.2*1.0) = 619.2 thousand tons

Scource: FAO (2011, p. 33–35).