“Assessment of ecological and economic efficiency of agricultural lands preservation”

AUTHORS	Dmytro Semenda https://orcid.org/0000-0003-2714-0436 http://www.researcherid.com/rid/C-5946-2018 Olga Semenda https://orcid.org/0000-0002-6690-645X http://www.researcherid.com/rid/C-5916-2018

ARTICLE INFO	Dmytro Semenda and Olga Semenda (2018). Assessment of ecological and economic efficiency of agricultural lands preservation. *Environmental Economics*, *9*(1), 47-56. doi:10.21511/ee.09(1).2018.04
DOI	http://dx.doi.org/10.21511/ee.09(1).2018.04
RELEASED ON	Monday, 16 April 2018
RECEIVED ON	Monday, 05 February 2018
ACCEPTED ON	Wednesday, 04 April 2018
LICENSE	This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License
JOURNAL	"Environmental Economics"
ISSN PRINT	1998-6041
ISSN ONLINE	1998-605X
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
27	1	6

Dmytro Semenda (Ukraine), Olga Semenda (Ukraine)

Assessment of ecological and economic efficiency of agricultural lands preservation

Abstract

The article substantiates the necessity to define and generalize the criteria for assessing the ecological and economic efficiency of using agricultural lands. Due to the transition of the agro-industrial complex to private forms of management, the problems of forming a strategy of rational, ecologically safe and sustainable development of land use in Ukrainian agriculture became of paramount importance. Therefore, systematic studies on the assessment of the ecological and economic efficiency of the agricultural land use need to be conducted. Harmonization of ecological and economic interests is of particular importance in the context of ensuring the conservation, resource-saving and reproductive nature of the agricultural land exploitation.

A scientific study found that in Ukraine, the agrarian sector of the economy provides about 47% of GDP, but the question arises: At what price are these achievements given to us? Agricultural land development exceeds environmentally sound standards. Excessive cultivation of the territory leads to an annual increase of eroded lands by 80-90 thousand hectares. Land use is recognized as environmentally unstable, and there is a steady tendency to deteriorate the quality of soil. Each second hectare of cultivated land is erosion-hazardous, that is, these soils are subject to water and wind erosion. In this regard, it is recommended to introduce the world-wide experience of Climate Smart Agriculture (CSA), which provides an opportunity to provide food security to the country and to limit the negative impact of the environment, based on the introduction of organic production.

It is proved that regardless of the size of farms and forms of management using resource-saving no-till technologies, enterprises received low cost of grown products, providing profitable activities. Ecological compatibility of the technology provides energy savings of at least 30% in comparison with traditional farming systems, the accumulation of not less than 30-40% of plant residues on the soil surface after harvesting of the predecessor, provides protection of the soil from wind and water erosion by minimizing the amount and depth of technological operations.

It is confirmed that the most widespread evaluation of the agricultural lands use is the evaluation of the results of their use through volumes of gross and commodity products, income, and production profitability. The criteria for the environmental effectiveness of agricultural land use should be: the degree of functional use of land resources, ecological stability, the level of anthropogenic loading, the degree of erosional feature of land, etc.

According to the study results, it was established that one of the main areas of agriculture is the application of minimal tillage in crop rotation, i.e. resource-saving no-till technology.

The economic feasibility of technologies based on the use of different soil tillage systems has been confirmed.

Keywords: soils, land resources, land use, soil erosion, land conservation, fertility, no-till, organic production, crop rotation
JEL Classification: Q10, Q15, Q24, R10, R14.
Received on: 05.02.2018
Accepted on:.04.04.2018

Introduction

Intensive development of agrarian production negatively affects the natural environment. The ecological situation has deteriorated in recent years, and the economic status of economic entities depends on it. One of the most important components of Ukraine's economic security is the provision of the ecological and economic component in the agrarian sector of the domestic economy.

The comprehensive state program of agriculture reforming and development in Ukraine stipulates that agriculture should develop on the basis of ecological technologies that ensure the soil fertility restoration, the recycling of organic waste, and the reduction of greenhouse gas emissions and compounds polluting the atmosphere. The principle of ecological safety management should minimize the negative effects of agricultural production and promote the reproduction of the natural potential of agroecosystems.

Modern agricultural technologies must combine the latest achievements of science and best practices and at the same time ensure high return on costs. For the successful development of agricultural

Dmytro Semenda, Professor, Ph.D. in Economics, Department of Enterprise, Trade and Exchange Activities, Uman National University of Horticulture, Ukraine.
Olga Semenda, Senior lecturer, Ph.D. in Economics, Department of Marketing, Uman National University of Horticulture, Ukraine.

production in Ukraine it is necessary to know the economic feasibility of technologies based on the use of different systems of basic soil cultivation. Only calculations of economic and environmental efficiency are the basis for these technologies introduction into agricultural production. Ecological and economic assessment as a result of scientific research is the final form of their consequences reflection.

1. Economic development and environmental situation of SEA

SEA historical and general background. SEA is prominently one of the largest economies leading the changes within the 21st century. With over 4,506,597 square kilometers, compared to the entire Asia region of 44,580,000 square kilometers, it has ten countries that are diverse and play an integral yet distinct role within the economies of SEA. The earliest history within the SEA is that it was dominated by Proto-Asiatic inhabitants over 63,000 years ago (Wayman, 2012). Fig. 1 shows the map of SEA geography that displays the 10 countries of the SEA region. The overall geography within the SEA region is surrounded with open waters, providing easy access to ports. Due to the ease of establishing ports around the coasts of SEA, the arrival of much more developed countries such as the Netherlands, Portugal, France, Spain, and the United Kingdom has provided links to the outside world.

Moreover, SEA has long been a central region for trade involving diverse peoples and sources of income and knowledge from around the world. The Europeans brought financing and investment opportunities that SEA never had. Currently, the ten countries that occupy SEA are as follows: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, the Philippines, Thailand, and Vietnam. Each country has become a major economic player in the global market. Table 1 describes the descriptive statistics for various indicators for the overall picture of the SEA within the 21st century. The largest country in the area within the SEA is Indonesia, while the smallest is Singapore. Countries in SEA are also home to numerous manufacturing factories that host many international brands outside SEA. This, coupled with overflowing resources of labor that are unmatched outside SEA, has provided the perfect stage for stable economic development.

The most interesting part of this dataset is how developing countries have begun to emerge within SEA in the 21st century. As shown in Table 1, countries that have the highest growth rate regarding economic development are Laos and Myanmar, while that with the lowest economic growth rate is Singapore. Similar performance occurs for GDP per capita. The highlight of this income difference is that countries within SEA have a high level of disparity. The 21st century has been quite kind to Laos and Myanmar. Laos for example has been able to restructure its economic infrastructure by enhancing the energy sector, which in turn has provided power for most of its significant economic development. Myanmar has also withdrawn its military from sensitive, important industries, thus allowing the economy to flourish. Furthermore, it is important to note that every country in SEA has positive economic development except Brunei.

2. Literature review

Given the transition of the agro-industrial complex to forms of management based on private ownership of land, the problem of shaping a strategy for rational, ecologically safe and sustainable development of land use in agriculture in Ukraine has become of paramount importance. A lot of Ukrainian and foreign scholars work on its development, namely Diesperov (2008), Kvasha (2011), Kliuchnyk (2011), Mesel-Veseliak (2011), Sabluk et al. (2009), Tranchenko (2012). The issues of resource providing of the reproduction process at the macro level were researched by Demianenko (2004), Fedorov (2009), Yakuba (2010), Xie and Johns (1995), and Griffin (1990).

The purpose of the article is to consider problems connected with the interconnection and interdependence of natural resource potential of rural territories and resource provision of agrarian production. System researches on the assessment of the ecological and economic efficiency of the agricultural lands use require further study, because the coordination of ecological and economic interests is of particular importance in the context of ensuring the environmental, resource-saving and reproductive nature of the agricultural land exploitation.

3. Research methodology

The article uses economic-statistical methods of research, in particular monographic, comparison, table and graphic.

4. Key research findings

Since the beginning of the current marketing year, as of January 1, 2018, Ukraine has exported more than 21.36 million tons of grain crops, in particular wheat – 11.2 million tons, barley – 3.7 million tons, and corn – 5.8 million tons (Cabinet of Ministers of Ukraine, 2018). In 2017, the gross grain harvest in Ukraine was 63 million tons, of which 40 million tons or 63% of the total production will be exported. Ukraine has always been the breadbasket of Europe and the bread supplier on world markets. But today the question arises: At what price are these achievements given to us?

More than 70% of land in Ukraine is agricultural land, of which 78.9% is arable land. This is the main part of the soil on which agriculture is managed, that is, it is cultivated and exploited to the fullest. On the one hand, this is good, because about 47% of the GDP is provided by the agrarian sector. The largest share in Ukrainian exports during the 10 months of 2017 belongs to agricultural products and food industry – 41.3% (Matsehora, 2018).

Under such conditions, the growth of agricultural production, which, on the one hand, is perceived as a positive phenomenon, due to an increase in food security and an increase in foreign exchange earnings, and, on the other hand, it poses a threat to the social and environmental spheres, which can ultimately largely neutralize the economic outcomes of such growth.

Ukraine has one of the highest indicators of agricultural development of territories (70.8%) and arable agricultural land (53.9%). Land use is considered to be environmentally unstable; there is an established tendency to deteriorate the qualitative state of soils: their acidification, de-structuring, and dehumidification (Ministry of Environment and Natural Resources, 2017).

The volumes of mineral fertilizers use decreased from 148 kg/ha of active substance in 1986–1990 to 76-96 kg/ha in 2011–2016 (Table 1).

Table 1. Applying mineral fertilizers in agriculture of Ukraine

Years	Mineral fertilizer used for 1 ha, kg a.s.			
	Nitrogen (N)	Phosphorous (P2O5)	Potassium (K2O)	Total (NPK)
1986-1990	65	41	42	148
2011	48	11	9	68
2012	50	12	10	72
2013	55	13	11	79
2014	57	13	12	82
2015	55	12	12	79
2011-2015	53	12	11	76
2016	67	16	13	96

For one hectare of arable land, only 0.5 tons of manure is applied instead of 9.4 tons applied in 1985 (Figure 1). Because of this, in agroecosystems, a stable negative balance of humus, nitrogen, phosphorus, potassium was formed (Table 2) (Baliuk, Danylenko, & Furdychko, 2017, p. 6)

.

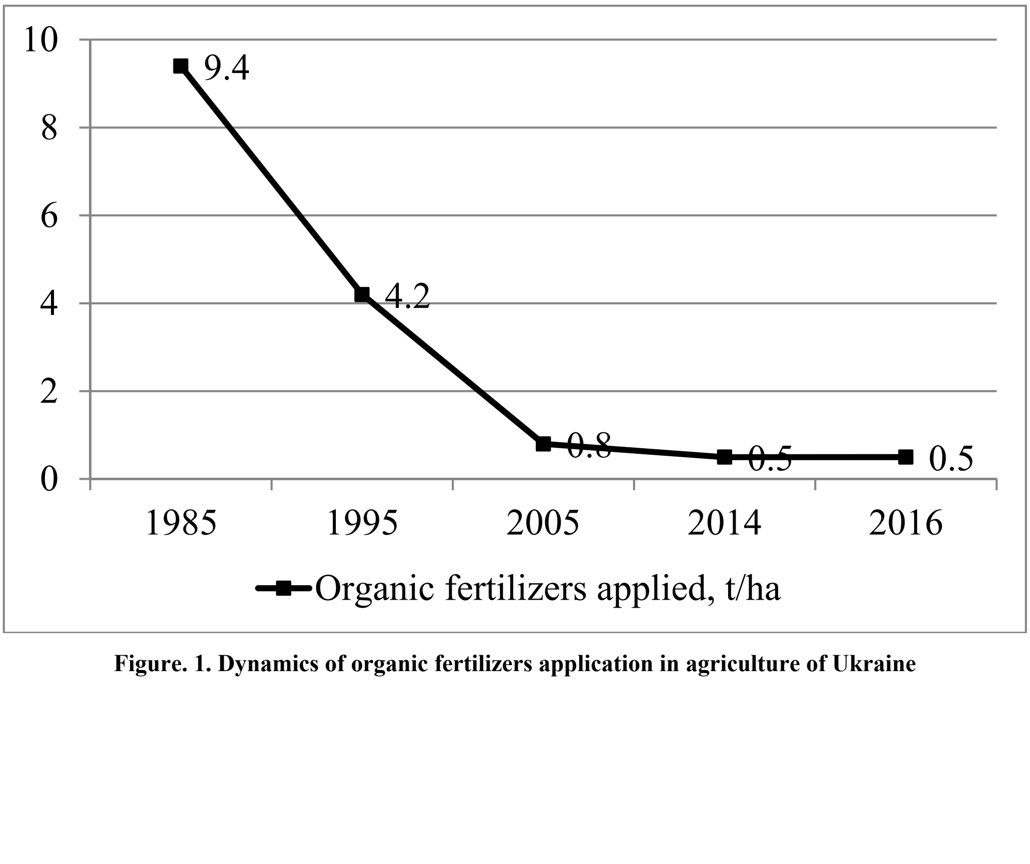

Figure. 1. Dynamics of organic fertilizers application in agriculture of Ukraine

Table 2. Dynamics of the balance of nutrient elements in agriculture in Ukraine

Balance items	Balance of nutrient elements, kg/ha a.s.			
	Nitrogen	Phosphorus	Potassium	Total (NPK)
1986–1990				
Receipts	89.5	56.1	102.7	248.3
Removal	92.6	31.2	103.2	227.0
Balance	–3.1	24.9	–0.5	21.3
1996–2000				
Receipts	26.0	10.4	15.3	51.7
Removal	56.5	18.2	53.7	128.4
Balance	–30.5	–7.8	–38.4	–76.7
2001–2005				
Receipts	21.8	5.9	8.7	36.4
Removal	70.1	24.7	76.7	171.5
Balance	–48.3	–18.8	–68.0	–135.1
2006–2010				
Receipts	38.7	10.2	14.7	63.6
Removal	77.4	23.9	60.3	161.6
Balance	–38.7	–13.7	–45.6	–98.0
2011–2015				
Receipts	65.0	13.1	18.1	96.2
Removal	85.0	25.4	33.2	143.7
Balance	–20.0	–12.3	–15.1	–47.5

High yields of agricultural crops are currently being achieved mainly due to natural soil fertility, which may decrease significantly in 5-10 years, as the average level of humus content in soils of Ukraine decreased from 3.64% in 1961 to 3.16% in recent years (Table 3).

Table 3. Dynamics of humus content in soils of Ukraine for the last 133 years

Natural and climatic zones	Average content of humus in an arable layer of soil, %			
	Year			
	1882	1961	1991	2015
Marshy scrub	2.44	2.30	1.98	2.33
Forest steppe	4.51	3.81	3.52	3.21
Steppe	4.49	3.96	3.63	3.45
Total in Ukraine	4.17	3.64	3.23	3.16

Another problem is that every second hectare of cultivated land is erosion-hazardous, that is, these soils are subject to water and wind erosion. Almost 15 million hectares were influenced by water and wind erosion, which is 35% of agricultural land. In recent years, the humus content has declined by an average of 20%, which negatively affects the productivity of each hectare of farmland. The process of soil formation of the fertile black humus earth has taken millions of years, so that in order not to lose it today, the main task of agriculture is to adhere to the following principles: yield must be adequate to the biological potential of crops, environmentally and economically justified, and the resulting products must be high-quality and environmentally safe, and certainly all this should contribute to the reproduction of soil fertility.

A serious threat to the environment is the violation of optimal standards for the introduction of mineral fertilizers, plant protection means, as well as the accumulation of hazardous waste and the limited financial resources of agrarian enterprises, unable to ensure the safe management of these wastes (Shkuratov, 2016, p. 75).

In this regard, let's elaborate a system of agricultural management such as CSA (Climate-Smart Agriculture), which was formed in response to the most powerful modern challenges for global agricultural production, namely the need to provide food security for increasing population, adaptation to climate change and limiting the negative environmental impact (Food and Agriculture Organization of the United Nations, 2018). At the heart of the CSA is the implementation of agricultural activities through methods that not only make it possible to achieve the desired agricultural production growth outcomes but also ensure its adaptation to climate change, as well as contribute to the reduction of greenhouse gas emissions (World Bank, n.d.).

One of the most common areas of CSA is organic production. Council Regulation (EU) No. 834/2007 on organic production and labeling of organic products defines such production as an "integrated system of food business management, which combines best practices in terms of environmental protection, the level of biological diversity, conservation of natural resources, the use of high standards of proper maintenance of animals and a production method that meets certain requirements for products manufactured using substances and processes of natural origin" (Council Regulation, 2007). Organic agriculture, along with unquestionable benefits for the environment, also contributes to the development of the countryside social sphere, since, according to the United Nations, an average of 30% labor is used more in this kind of production than in traditional agriculture.

In Ukraine, the area of certified agricultural land involved in the cultivation of various organic products is 411 thousand hectares, and Ukraine holds the honorable twentieth place of the world leaders of the organic movement. The share of certified organic areas among the total agricultural land in Ukraine is about 1%. At the same time, Ukraine occupies the first place in the Eastern European region regarding the certified area of organic arable land, specializing mainly in the production of cereals (wheat, barley, corn) – 197 thousand hectares, oilseeds (sunflower and rape) – 67 thousand hectares. The areas under cultivation of organic vegetables exceed 8 thousand hectares, and for organic potatoes – 1,200 hectares (AgroPortal, 2017).

Official IFOAM statistical surveys confirm that if, in 2002, there were 31 farms registered as organic in Ukraine, then, in 2016, there were already 360 certified organic farms. The domestic consumer market for organic products in Ukraine began to develop from the beginning of the 2000s, amounting to 400 thousand euros in 2006, and to 21.2 million euros in 2016 (Federation of Organic Movement of Ukraine, n.d.). But the resource potential of Ukraine is able not only to supply organic products to its own population, but also to produce them in significant volumes for export.

Given the experience of research and analysis of land use indicators, it is known that the environmental and economic assessment of the agricultural land use should be based on the assessment of the scale and intensity of the economic activity impact on the state of land resources. Indeed, at the present stage, the desire of the agricultural producers to obtain maximum profit leads to adverse environmental consequences (Palianychko, 2011, p. 19).

Let's consider the criteria for assessing the economic efficiency of agricultural land use. One of the most common areas for assessing land use is the evaluation of their use results, in particular through volumes of gross products, commodity products, income, profitability of production, etc.

However, if the calculation of income and profitability of production in specific enterprises gives a certain idea of the effective land use, then at national and regional levels it is impossible to accurately estimate the land use effectiveness through these indicators, which is due to a number of reasons (Tretiak, 2013, p. 136):

- firstly, efficiency is often considered as savings, that is, in reality, the pursuit of efficiency turns into a desire to reduce costs, not to improvement;
- secondly, socially necessary costs are more difficult to determine than economic costs; often, in practice, external factors of influence on the efficiency of agricultural land use are not taken into account; and
- thirdly, the economic benefits are easier to detect than social ones, and when attempting to artificially increase efficiency, one substitutes one criterion, which is easier to calculate.

The main criteria for the ecological efficiency of agricultural land use should be the degree of functional use of land resources, ecological stability, the level of anthropogenic loading, the degree of erosional feature of lands, etc.

So, let's consider a number of factors that not only ensure high yields, profitability of production, but also maintain the agricultural land fertility, improve environmental ecology. To that end, take the Cherkasy region for a model.

In the late 60s of the last century, Cherkasy region initiated an intensive chemization of agricultural production. Annually 180 kg of nutrient elements from mineral fertilizers and 10 tons of manure were applied, and also chalking was carried out on the area of 120 thousand hectares at the expense of the state. As a result, in two decades, the content of nutrients increased in the soil of the region and stabilized the content of organic matter, which provided for the cultivation of some of the highest crop yields in Ukraine.

Extensive agricultural management has sharply worsened the balance indicators of nutrients and humus in the land resources of the region (Table 4). Applying less than one ton of organic fertilizers (manure) per hectare of arable land, the burning of a large quantity of non-market products have led to a steady negative balance of organic matter in the agriculture of the region. After all, the annual loss of about 0.5 tons of humus per hectare leads not only to the loss of nitrogen from the soil, but also to the deterioration of the physical properties of soils, which determine their fertility. Since 2007, there has been a tendency in the number of fertilizers applied. But the removal of nutrients by the harvest outstrips this increase, so the negative balance of nutrition in the agriculture region continues.

Table 4. Rating of districts of the Cherkasy region on the content of humus

Source: Compiled based on Baliuk et al. (2017)

No. of district	Name of the district	Humus content, %		
		1981–1985	1991–1995	2009–2013
2	Drabiv	4.36	3.76	3.82
3	Zhashkiv	3.78	3.90	3.39
14	Talne	3.52	3.38	3.38
8	Katerynopil	3.61	3.42	3.37
16	Khrystynivka	3.41	3.26	3.26
15	Uman	3.37	3.40	3.29
19	Chornobai	3.65	3.60	3.23
12	Monastyryshche	3.37	3.24	3.21
20	Shpola	3.64	3.22	3.21
10	Lysianka	3.38	3.08	3.09
1	Horodyshche	3.06	2.96	2.99
5	Zolotonosha	3.28	3.50	2.97
11	Mankivka	3.11	3.00	2.88
4	Zvenyhorodka	2.80	3.00	2.80
6	Kamianka	3.04	3.02	2.73
13	Smila	2.92	2.70	2.58
17	Cherkasy	2.35	2.52	2.42
9	Korsun-Shevchenkivskyi	2.38	2.65	2.30
7	Kaniv	2.29	2.82	2.29
18	Chyhyryn	2.49	2.80	2.27
Across region		3.27	3.25	3.05

The average weighted index of humus content in the soils of Cherkasy region is 3.05%, or decreased by 0.03% compared to the previous round of the survey. In all areas surveyed, there is a decrease in humus content from -0.06% in the Chyhyryn district to -0.21% in the Smila district. The greatest losses were detected in areas where light mechanical soils are prevalent. In particular, farms in Zolotonosha, Chernobai, and Cherkasy districts lost 400 to 600 kilograms of humus per hectare.

The modern system of farming is based on the principle of obtaining the net profit of crop production with its minimum material and monetary costs (economic approach). However, such an approach contradicts the modern understanding of agriculture, which is based on the exploitation of soils, which does not allow reducing its fertility. Therefore, in addition to the economic criterion, it is also necessary to apply an ecological one, namely the calculation of the balance of nutrients and humus.

Humus is the material carrier of fertility, so all its conservation measures should be aimed at reducing unproductive losses of humus and soil replenishment with organic matter.

An important source of replenishment of organic matter (humus) and soil nitrogen, increasing its fertility is the use of seed crops as organic fertilizers (Table 5).

Table 5. Recommended amounts of green manure crop in Cherkasy region, the hectares

District	2016 - 2020
Horodyshche	23.7
Drabiv	47.4
Zhashkiv	42.0
Zvenyhorodka	31.5
Zolotonosha	37.0

Table 5 (cont.). Recommended amounts of green manure crop in Cherkasy region, the hectares

District	2016 - 2020
Kamianka	21.8
Kaniv	28.2
Katerynopil	28.2
Korsun-Shevchenkivskyi	21.6
Lysianka	25.6
Mankivka	28.2
Monastyryshche	28.2
Smila	28.2
Talne	34.6
Uman	49.1
Khrystynivka	26.2
Cherkasy	26.2
Chyhyryn	26.2
Chornobai	26.5
Shpola	20.4
Total across region	640.0

Green fertilizers should also be considered as a means of reducing the processes of water and wind erosion. In the conditions of the Cherkasy region more effective green manures were cruciferae family cultures (mustard, oil radish, spring and winter turnip, etc.). If sown at the end of July – in the first decade of August, they quickly increase the green mass and after 40-60 days of vegetation produce a yield of 200-350 centner/ha. It is expedient to plant them out as green fertilizer under the spring cultures in the first half of October.

The annual expenditures on green manures will be UAH 103,387 ths or 10.7% in the structure of the cost for the main measures to preserve the soil fertility in the region.

In Ukraine, over the past 20-30 years, zonal differentiated soil tillage systems have been developed based on the use of traditional polygonal and non-polygonal methods of cultivation with different depth, number of operations and a set of tools.

Under intensive agriculture, the use of minimal soil cultivation in crop rotation, that is, resource-saving no-till technology (or direct sowing technology), is decisive.

Analysis of the conference proceedings on the experience exchange of the no-till technology use, which took place in Ukraine in 2004–2009 involving the practicing expert consultants, farmers, researchers from more than 20 countries from five continents in the world, indicates the following:

1. Examples of successful long-term experience of using no-till technology exist everywhere in the world, where crop farming is practiced regardless of climatic conditions (rainfall, temperature regime), type of soils, kind of cultivated grains, leguminous crops.

2. Practitioners unanimously note the following positive effects from the no-till technology use:

- fuel economy (reduction of energy intensity);
- increase of moisture content in soil, improvement of water availability;
- reduction of soil erosion;
- increase in the crop production stability;
- growth of profit in farms of any size (including small ones);
- net profit growth.

3. no-till technology reduces the need for physical labor, but needs much more intellectual and mental activity and appropriate level of professional knowledge and skills.

4. The technology has no objective contraindications to use. Obstacles can only be reluctance (fear) to change habitual methods of work (lack of motivation) or low level of professional training of agricultural producers.

In the world, there are examples at the country level indicating the possibility of a significant increase in yield in the transition to no-till technology. For example, due to the introduction of no-till technology in the western state of Austria, the total revenue growth amounted to USD 2.1 billion (Crabtree, 2010).

In the Uman district of Cherkasy region, most agricultural enterprises refused to cultivate land with a plow. LLC "Tekucha" initiated surface cultivation of land after sunflower, corn, winter and spring grains. Having created a joint Ukrainian-German enterprise in 1994, the company had enough adequate equipment for surface soil cultivation and agricultural cropping. Then, LLC "Dubova", LLC "Berestivets" and others did the same.

More than 7 years ago APC "Cherpovody" introduced no-till. The company acquired a seeding-machine SF9412-20 to sow crops without the traditional land cultivation: winter wheat, barley, corn, and sunflower. The consumption of diesel fuel by the company has decreased by half. If before the transition to no-till, the enterprise spent 200 tons of diesel fuel, then it was 100 tons to be spent, saving of UAH 1,500 thousand took place in only for diesel fuel. The cost of human labor and cultivation of land have decreased significantly. Under usual technology after winter wheat, the following operations were carried out: discarding, plowing, moisture closing, cultivation, sowing, rolling; in contrast, with no-till all these technological operations are not carried out – at a time they sow and receive young crops. This kind of cultivation gives particularly good effect in arid years.

Let's consider the economic efficiency of crop production at the enterprises that grow products by mini-till, no-till and traditional technologies (Table 6).

Table 6. Productivity and cost of production of agricultural crops at the enterprises of Uman district of Cherkasy region for 2013-2016

Crop	LLC "Tekucha"		APC "Cherpovody"		LC "Prometei"	
	Mini-till		No-till		Traditional	
	Yield, centner/ha	Manufacturing cost, 1 centner, UAH	Yield, centner/ha	Manufacturing cost, 1 centner, UAH	Yield, centner/ha	Manufacturing cost, 1 centner, UAH
Winter wheat	40.4	98.64	39.3	83.0	43.3	92.80
Spring barley	25.3	122.67	28.8	64.63	30.9	88.05
Grain maize	63.7	84.10	70.5	80.75	82.3	67.53
Sunflower	25.0	185.88	19.7	174.36	23.5	138.78

Source: Calculated by the authors based on f.-50 a.c.

Given the economic efficiency of the crop rotation of the investigated enterprises (the calculation is made in grain units), the data confirm that the no-till technology has a basis for existence, while not taking the ecological-preserving factor into account (Table 7).

Table 7. Economic efficiency of crop rotation at the enterprises investigated

Indicator	APC "Cherpovody", Uman district *No-till*	LLC "Prometei", Uman district *Intensive technologies with the use of domestic equipment*	LLC "Verkhniachka-Ahro", Khrystynivka district *Intensive technologies with the use of domestic equipment*
1. Area under crops, ha	1000	1600	1280
2. Yield from 1 hectare, centner of crops	64,0	65,9	66,95
3. Gross output, centner of crops	64050	105360	85696
4. Labor costs for output production, person-hours	7648	16980	24414
5. Labor intensity of 1 centner of crops, person-hours	0,12	0,161	0,28
6. Manufactured for 1 person-hour, centner of crops	8,4	6,2	3,51
7. Cash costs for 1 hectare, UAH	5778	7068	7080
8. First costs of 1 centner cops, UAH	90,30	107,25	105,75
9. Cash costs for gross product production, UAH ths	5778	11308,0	9262
10. Sale price of 1 centner crops, UAH	304,60	303	277,10
11. Gross product value at sale prices, UAH ths	19510	31808	23747
12. Gross product manufactured for 1 person-hour, UAH	2551	1873	973,0
13. Profit on sales, UAH ths	13732	20500	14485
including for 1 ha, UAH	13732	12812	11316
14. Level of profitability, %	237.7	181.3	156.4

Source: Calculated by authors based on f.-50 a.c.

In modern soil protection systems of agriculture, zero tillage of soil should provide:

- energy saving not less than 30-45% compared to traditional farming systems;
- protection of soil from wind and water erosion by minimizing the amount and depth of technological operations;
- accumulation of at least 30-40% of plant residues on the soil surface after harvesting of the predecessor.

This ensures reduction of the intensity of erosion processes and increase in the coefficient of atmospheric precipitation use, as well as reducing the intensity of physical evaporation of soil moisture by 15-25%

To ensure rational use and protection of land, the decision of the Cabinet of Ministers of Ukraine dated November 2, 2011 No. 1134 "On approval of the Procedure for the development of land management projects that provide ecological and economic rationale for crop rotation and land management" obligated land users and landowners to develop a land management project by January 1, 2013. It should have taken into account the norms of the optimal ratio of crops in crop rotation in different natural and agricultural regions approved by the resolution of the Cabinet of Ministers of Ukraine No. 164 dated February 11, 2010.

In all soil-climatic zones of Ukraine, all agricultural systems have common constituents that reflect the two main features of their formation: the way of using the land and the way to improve soil fertility.

Each system of agriculture must be economically justified and set up taking local natural (soil, climatic) and economic conditions into account.

Conclusion

It was established that the main instrument of the state land use strategy should be the ecological and economic mechanism of rational land use. To do this, it is proposed to stimulate enterprises to widely introduce soil-protecting technology of farming based on zero soil cultivation. The introduction of protective agriculture has clear economic benefits (economic calculation of the APC "Cherpovody", Uman district and other agricultural enterprises operating on the basis of conventional technology).

Consequently, the ecological and economic mechanism for preserving the fertility of agricultural land should have the following components:

- introduction of organic agriculture, zero technology of soil cultivation, scientifically grounded correlation of lands;
- preservation, reproduction and increase of soil fertility;
- ecologization of land use on the basis of sustainable development.

However, all modern agrotechnologies in agriculture must combine the latest achievements of science and best practices and at the same time provide high return on costs. It is necessary to calculate the economic feasibility of technologies that are based on the use of different soil tillage systems. Only calculations of economic and energy efficiency are the basis for the introduction of these technologies into agricultural production.

References

1. AgroPortal (2017). *Україна – 20-та в світі за органічними угіддями [Ukraina – 20-ta v sviti za orhanichnymy uhiddiamy]*. Retrieved from http://agroportal.ua/ua/news/ukraina/ukraina-20ya-v-mire-po-organicheskim-ugodiyam/
2. Baliuk, S. A., Danylenko, A. S., & Furdychko, O. I. (2017). Звернення до керівника держави щодо подолання кризової ситуації у сфері охорони земель [Zvernennia do kerivnyka derzhavy shchodo podolannia kryzovoi sytuatsii u sferi okhorony zemel]. *Visnyk Ahrarnoi Nauky,* 5-8.
3. Cabinet of Ministers of Ukraine (2018). *Зернові утримують стабільність [Zernovi utrymuiut stabilnist]*. Retrieved from https://ukurier.gov.ua/uk/news/zernovi-utrimuyut-stabilnist/
4. Council Regulation (EC) No. 834/2007 of 28 June 2007 on organic production and labeling of organic products and repealing Regulation (EEC) No. 2092/91. Retrieved from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:189:0001:0023:EN:PDF
5. Crabtree, B. (2010). *Програми реформ та розвитку сільського господарства України [Prohramy reform ta rozvytku silskoho hospodarstva Ukrainy]*. Retrieved from http://33.stopref.ru/programi-reform-ta-rozvitku-slskogo-gospodarstva-ukrani-1-dokument.html
6. Demianenko, S. I. (2004). До питання про стратегію розвитку аграрної політики України [Do pytannia pro stratehiiu rozvytku ahrarnoi polityky Ukrainy]. *Ekonomika Ukrainy, 8,* 72-79.
7. Diesperov, V. S. (2008). *Ефективність виробництва у сільськогосподарському підприємстві [Efektyvnist vyrobnytstva u silskohospodarskomu pidpryiemstvi]* (340 p.). Kyiv: Instytut Ahrarnoi Ekonomiky.
8. Federation of Organic Movement of Ukraine (n.d.) *Органік в Україні [Orhanik v Ukraini]*. Retrieved from http://organic.com.ua/uk/homepage/2010-01-26-13-42-29

9. Fedorov, M. M. (2009). Трансформація земельних відносин до ринкових умов [Transformatsiia zemelnykh vidnosyn do rynkovykh umov]. *Ekonomika APK, 3,* 11.
10. Food and Agriculture Organization of the United Nations (2018). *Climate Smart Agriculture*. Retrieved from http://www.fao.org/climate-smart-agriculture/en /
11. Griffin, R. W. (1990). *Management* (884 p.). Boston: Houghton Mifflin Company.
12. Kliuchnyk, A. V. (2011). Зайнятість населення сільських територій: проблеми та стратегічні напрями їх вирішення [Zainiatist naselennia siskykh terytorii: problemy ta stratehichni napriamy yikh vyrishennia]. *Rehionalna Ekonomika, 1,* 134-139.
13. Kvasha, S. M. (2011). Напрями удосконалення механізмів формування ринкової рівноваги на ринках сільськогосподарської продукції [Napriamy udoskonalennia mekhanizmiv formuvannia rynkovoi rivnovahy na rynkakh silskohospodarskoi produktsii]. *Ekonomika APK, 2,* 161-167.
14. Matsehora, K. (2018). Найбільше товарів країна експортує до ЄС [Naibilshe tovariv kraina eksportuie do YeS]. *Uriadovyi Kurier, 2*. Retrieved from https://ukurier.gov.ua/uk/articles/najbilshe-tovariv-ukrayina-eksportuye-do-yes/
15. Mesel-Veseliak, V. Ya. (2011). Економічні передумови забезпечення розширеного відтворення сільськогосподарського виробництва в Україні [Ekonomichni peredumovy zabezpechennia rozshyrenoho vidtvorennia silskohospodarskoho vyrobnytstva v Ukraini]. *Ekonomika APK, 3,* 9-16.
16. Ministry of Environment and Natural Resources (2017). *Національна доповідь про стан навколишнього природного середовища в Україні у 2015 році [Natsionalna dopovid pro stan navkolyshnioho pryrodnoho seredovyshcha v Ukraini u 2015 rotsi]*. Retrieved from https://menr.gov.ua/news/31768.html
17. Palianychko, N. I. (2011). Стале землекористування як головний критерій еколого-економічної оцінки використання земель сільськогосподарського призначення [Stale zemlekorystuvannia yak holovnyi kryterii ekoloho-ekonomichnoi otsinky vykorystannia zemel silskohospodarskoho pryznachennia]. *Ekonomika APK, 2,* 18-22.
18. Sabluk, P. T., Mesel-Veseliak, V. Ya., & Fedorov, M. M. (2009). Аграрна реформа в Україні: здобутки, проблеми і шляхи їх вирішення [Ahrarna reforma v Ukraini: zdobutky, problem i shliakhy yikh vyrishennia]. *Ekonomika APK, 12,* 3-13.
19. Shkuratov, O. I. (2016). Страхування екологічних ризиків сільськогосподарської діяльності в системі забезпечення екологічної безпеки [Strakhuvannia ekolohichnykh ryzykiv silskohospodarskoi diialnosti v systemi zabezpechennia ekolohichnoi bezpeky]. *Ekonomika APK, 5,* 74-79.
20. Teremets, L. A. (n.d.). Система показників ефективності використання земель усільському господарстві [Systema pokaznykiv efektyvnosti vykorystannia zemel u silskomu hospodarstvi]. *Zb. nauk prats PDAA, Seriia: Ekonomichni Nauky, 5*(5), 304-309.
21. Tranchenko, L. V. (2012). Аналіз та проблеми соціально-економічного розвитку села [Analiz ta problem sotsialno-ekonomichnoho rozvytku sela]. *Investytsii: Praktyka ta Dosvid, 5,* 66-69.
22. Tretiak, N. A. (2013). Підходи до оцінки ефективності управління земельними ресурсами та землекористуванням [Pidkhody do otsinky efektyvnosti upravlinnia zemelnymy resursamy ta zemlekorystuvanniam]. *Zemleustrii, kadastr i monitorynh zemel, 1,* 136-146.
23. World Bank (n.d.). *Climate Smart Agriculture. A Call to Action*. Retrieved from http://www.worldbank.org/content/dam/Worldbank/document/CSA _Brochure_web_WB.pdf
24. Xie, J., & Johns, C. (1995). Jobscope and Stress: Can jobscope be too high? *Academy of Management Journal, 5,* 128-309.
25. Yakuba, K. I. (2010). Безробіття селян: економічний і соціальний аспект [Bezrobittia selian: ekonomichny i sotsialnyi aspekt]. *Ekonomika APK, 6,* 107-112.
26. Агропромисловий комплекс України: стан та перспективи розвитку [Ahropromyslovyi kompleks Ukrainy: stan ta perspectyvy rozvytku] (2009). Naukovyi Zbirnyk.
27. Держгрунтохорона [Derzhgruntokhorona] (2014). *Агрохімічна характеристика та стан родючості ґрунтів Черкаської області 2014 року [Ahrokhimichna kharakterystyka ta stan rodiuchosti gruntiv Cherkaskoi oblasti 2014 roku]* (17 p.). Kholodnianske.