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Seed Production of Winter Cereals – the Basis of National Selection and the Task of Ukrainian Breeding Science in 2022

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► **Abstract.** The strategic importance of grain as a commodity in the domestic market and the main export agricultural commodity determines the relevance of the study. Today, the problem of high-quality seed production in Ukraine has worsened, as insufficient funding for the industry, outdated material and technical base of breeding organisations, scarce royalties and lack of breeding payments threatens the development of Ukrainian seed production. The dynamic development of the industry requires a more active and balanced policy in the industry, which would include state target programmes and the development of the regulatory framework in terms of ensuring legal and transparent intellectual property rights to breeders and breeding institutions. The purpose of the article is to analyse and assess the state of seed production of winter cereals and determine the objectives of Ukrainian breeding science for 2022. The following methods were used in the research process: dialectical, systematic approach, monographic, economic-statistical, tabular, graphical, empirical, comparative analysis, abstract-logical, analytical forecasting. The state of seed production of winter cereals was studied and it was found that in Ukraine there are 583 varieties of wheat, 79 – barley, 55 – rye and 51 – triticale. Only 32% of wheat, 33.3% of triticale, 17.7% of barley and 5.5% of rye are produced. Of these, Ukrainian is only 58.3% for wheat, 47.5% for barley and 15.5% for rye; the average annual need for winter cereals in the regions of Ukraine and in the country as a whole was determined. 1.4-1.6 million tons of wheat, 122 thousand tons of barley, 36 thousand tons of rye and 10 thousand tons of triticale are needed to ensure the sowing of grain in volumes not less than the sown area; tasks for Ukrainian breeding science on the development of winter cereals for 2022 are set, which will contribute to technical and technological support of breeders and seed producers, harmonisation and adaptation of the seed industry of Ukraine to world standards, increase competitiveness and the export potential of Ukrainian seed production

► **Keywords:** grain production, conditioned seeds, selection, market, variety, seed production system, additional and basic seed production

► Introduction

The national grain economy occupies a central place in the country's agricultural production [1] and guarantees its food security, which is why it is considered an area of strategic importance. In addition, grain production is the main activity for most agricultural enterprises. Therefore, more attention should be paid to the development of this activity. This will allow agricultural enterprises to increase their profits. After all, favourable geopolitical and territorial-economic position, favourable soil and climatic conditions have defined Ukraine as one of the main grain countries in the world. At the same time, the volume of grain in the export potential of the state is constantly growing. If in the 2013/2014 marketing year grain exports from Ukraine amounted to 32.5 million tons, in 2019/2020 – 57.2 million tons [2]. That is why the competitiveness of grain products will largely determine the competitiveness of Ukraine in the global agricultural market. At the same time, qualitative indicators of grain products and seed exports offered on the market become especially important in market conditions. This can be achieved primarily through well-organised and efficient seed production of cereals of Ukrainian selection.

In today's conditions of agricultural production there are many unresolved issues related to the prospects for the development of conditional seed production of grain crops in Ukraine. The main ones are: low

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level of provision of Ukrainian agricultural producers with seeds of higher categories [3]; dominance of imported varieties [4]; lack of mandatory declaration of varietal production crops; imperfect legal norms on royalty and selection payments in Ukraine; limited state support for the seed industry. The solution of these problems will contribute to the provision of national producers with seeds of Ukrainian selection, the establishment of exports of winter cereals, additional investment in the development of selection and seed production. They are gaining dynamism, need more thorough research and identify ways to solve them.

To determine the scale of problems in the field of seed production and find ways to solve them, it is necessary to analyse and assess the state of seed production of winter cereals and set goals for Ukrainian breeding science in 2022.

Based on the research, the current state of the organisation of the system of winter cereal production in Ukraine is summarised, proposals for improving the current state of Ukrainian conditional seed production are developed and the main tasks of Ukrainian selection for the future are formed.

Issues related to the development of the seed industry, improving the efficiency of the seed system and the further strategy of the industry are the research of many Ukrainian and foreign scientists.

O.P. Caviglia, R.H. Rizzalli, J.P. Monzon, F.O. García, R.J.M Melchiori, J.J. Martinez, A. Cerrudo, A. Irigoyen, P.A. Barbieri, N.V. van Opstal, F.H. Andrade [5] study the increase of economic efficiency of production and yield of grain crops depending on different agronomic methods of growing grain. Maximising yields through maximum use of various natural and logistical resources, tillage technologies, crop rotations. Ensuring food security for the world by increasing grain yields on the same or smaller area and with minimal impact on the environment.

In their studies, A. Klimek-Kopyra, M. Bacior, T. Zając [6] analyse the productivity of the main winter cereals – wheat, rye and triticale. The role of winter cereals in food security in both developed and developing countries is considered. In addition, the authors, like the previous ones, study the dependence of winter cereal yields on natural factors such as natural disasters, droughts, diseases and pests.

The same researchers study the nutritional value and yield of single and interspecific grains and their impact on overall crop productivity.

A.-J. Albert, M. Bitomský, L. Götzenberger, O. Mudrak, J. Klimešová [7] study the reproduction of grass seeds and their productivity depending on their growing conditions, species, and M.B. Khan, A. Khaliq [8] – the economic efficiency of growing depending on crop rotations.

J.B. Ang, P.G. Fredriksson [9] studied the efficiency of wheat production on family farms, and D. Nabuuma, C. Reimers, K.T. Hoang, T.J. Stomph, K. Swaans, J.E. Raneri [10] – the role of seed systems in providing seeds to the same category of farms. They include in seed systems technologies, organisational institutions, market and non-market institutions through which seeds are accessed. The official seed system is guided by plant breeding and breeding methodologies, which are mainly used by the public or private sector, including official regulation, certification and laws. Small farms, in their opinion, regardless of geographical affiliation, usually do not use conditioned seeds, conditioned upon its high cost. The use of certified seeds is typical of large and medium-sized agricultural producers.

The role of seed systems in the development of agricultural production and providing agricultural producers with certified seeds was considered by Ukrainian scientists Y. Lupenko, A. Hutorov, O. Dorokhov and, in fact, O. Zakharchuk [11]. The main directions of their research are the analysis of the current state and prospects of seed production development in Ukraine; creation of an integrated market infrastructure of plant varieties, all components of which would work in a coordinated economic regime and ensure the most efficient sale of seeds and risk sharing in the process of its production and sale; solving the problems of commercial turnover of seeds and planting material and payments for the use of intellectual property.

In the analysed studies on the topic of seed production, mainly agronomic and, rarely, economic studies are presented. Therefore, the results presented in the article are relevant, timely and necessary.

▸ Materials and Methods

The methodological basis of the study is the dialectical method of cognition and a systematic approach to the study of economic features of seed production in Ukraine. At the same time, the following methods were used in the research process: monographic (in highlighting the views of scientists on the issues and problems studied in the work, in analysing the current state of production of winter grain seeds); economic and statistical (to study the specific features of the development of winter cereal production in the NAAS system, to reflect the state of Ukrainian seed production in quantitative and cost terms through a system of absolute and relative indicators); tabular and graphical (with visual display of research results in the form of figures and tables), empirical (for a comprehensive assessment of the effectiveness of seed use); comparative analysis (to identify the main problems of seed production of winter cereals in Ukraine); method of analytical forecasting (to determine the tasks and recommendations on the organisational and economic mechanism of seed production in Ukraine), abstract and logical (generalisation and formulation of conclusions).

The main stages of the study are: analysis and systematisation of research of Ukrainian and foreign scientists on grain production and seed production of grain crops; analysis of production of conditioned seeds of winter cereals in Ukraine by producers, varieties and volumes; the share of seeds of Ukrainian selection in the total volume of winter grain seeds was determined; the average annual need for winter grain seeds s calculated considering the sown areas by regions and sowing norms by regions of Ukraine; the main tasks were identified and recommendations were made to improve the condition of Ukrainian conditional seed production to adapt

it to world requirements and strengthen its export potential.

The average annual need for seeds for the main types of winter cereals was determined considering the sown areas by regions of Ukraine and sowing rates for each of the crops.

The information base of the research was the works of Ukrainian and foreign scientists, reference and information publications, materials of scientific and practical conferences, information and analytical materials of research institutions, materials of personal observations of the authors.

Calculations were made based on the Ministry of Agrarian Policy and Food of Ukraine (production of conditioned winter grain seeds in general and by regions, producers, varieties, volumes of Ukrainian and foreign seeds) [4], State Statistics Service (sown areas) [12], Ukrainian Institute examination of plant varieties (number of varieties in the state register) [13] and own calculations.

▸ Results and Discussion

The strategic importance of grain seed production is revealed through the system of functioning and development of the country's grain economy. Cereal seeds as sowing material are a prerequisite for the grain production process and cannot be replaced by any other factor of production. One of the main factors in the intensification of grain production is high-quality sowing material and high-yielding varietal resources of national selection. They are the main factor in obtaining high yields and expanding the process of grain production in a sharp reduction in the application of mineral and organic fertilizers, plant protection products [14, p. 221].

Because productive varieties and conditioned seeds of grain crops are one of the key and indispensable factors influencing the intensification and expansion of the grain production process. Among winter cereals, productive varieties are those that have not only high yields, but also resistant to freezing and drought, diseases, adapted to a certain natural and climatic zone. Among the varieties of winter wheat are: Bogdana, Podolyanka, Wisdom of Odesa, Katrusya of Odesa, Astarta; Sofia Kyivska, League of Odesa, Landscape, Oranta Odesa, Shestopalivka (Ukrainian), RZHT Reform, Skagen, Julia, Tobacco, Kubus, Patras, Artist Ethan, KVS Jersey (foreign); winter barley Ninth Shaft, Snow Queen, Worthy and Valkyrie (Ukrainian), Luran, Leicester, KVS Tenor, Lucien, Isocel, Highlight, Hannelore, Maibrit (foreign) [4].

According to the Law of Ukraine "On Seeds and Planting Material" of 12/26/2002 No. 411-IV "conditioned seeds – seeds whose varietal and sowing qualities meet the requirements established by legislation in the field of seed and nursery" [15]. In Ukraine, DSTU 2240-93 [16], DSTU 2949-94 [17] and DSTU 4138-2002 [18] are legally approved. These are the standards according to which the produced, certified and sold seeds are controlled.

Intensification of grain production in today's conditions, according to I.V. Kuzmenko [19] is also possible by mastering modern innovative technologies. The same opinion is shared by other researchers. E.N. Simonyan and M.O. Yandola [20] in the first place put innovative technologies and, at the same time, emphasise the impossibility of their implementation conditioned upon limited funding for the industry. And it is impossible to disagree with this, because the lack of state programmes for the development of the industry, outdated material and technical base of breeding institutions and the lack of royalties and breeding payments make it impossible to renew production at a sufficient level for modern conditions. This indicates that the focus today should be the system of economic relations in the field of seed production of grain crops, as a separate organisational and economic link of the grain complex of the state.

From the agro-technological and production-economic standpoint, the main task of the seed industry, both grain and other crops, is to reproduce (produce) seeds of high-yielding varieties, to preserve and improve its purity and yield properties. The level of efficiency of an important and integral component of the grain production system – the process of variety replacement and variety renewal [21] depends on the efficiency of the system of seed production of grain crops.

An important role in increasing the yield and gross harvest of grain products is played by winter cereals, which are the basis of food security and a source of strategically important raw materials for many branches of the processing industry. In addition, they play a special role in providing a forage base. Winter cereals occupy about 7.5-8.0 million hectares of crops [12]. Winter wheat is the leader in terms of sowing and gross harvest in world grain production with a sown area of up to 6.9 million ha [12]. In Ukraine, it is the main food and export crop. Also winter cereals include winter barley (sown area of about 1.0 million hectares), winter rye (sown area of 150-200 thousand hectares) and winter triticale (sown area of 10-15 thousand hectares) [12].

In 2021, the production of certified seeds of winter soft and durum wheat amounted to 112.1 thousand tons, including its imports amounted to 0.6 thousand tons, as well as 39.2 thousand tons of seeds of foreign selection produced in Ukraine (Table 1). The share of Ukrainian seed production was 65 % (73,3 thousand tons) of the total result. It has decreased by almost 20 % over the last decade.

Table 1. Production of conditioned seeds of winter wheat in Ukraine for sowing in 2022

Regions	Ukrainian production				Foreign production of foreign selection		Total	
	Ukrainian selection		Foreign selection					
	Tons	Number of varieties	Tons	Number of varieties	Tons	Number of varieties	Tons	Number of varieties
Vinnytsya Region	1927.2	23	1604.0	11		–	3531.2	34
Volyn Region	–	–	1788	10	–	–	1158	10
Dnipropetrovsk Region	8126.1	36	1275	8	–	–	9401.1	46
Donetsk Region	1497.9	17	0	–	120	–	1497.9	17
Zhytomyr Region	394.5	6	2845.0	10	1.2	3	3240.7	19
Zakarpattia Region	1	–	10.5	–	–	–	10.5	1
Zaporizhzhya Region	3285.3	28	–	–	–	–	3285.3	28
Ivano-Frankivsk Region	–	–	–	–	–	–	–	–
Kyiv Region	4247.7	69	1760.0	22	191.46	16	6199.2	92
Kirovograd Region	165.1	10	848.2	4	–	–	1013.3	14
Luhansk Region	550	9	–	–	–	–	550	9
Lviv Region	174.9	8	110.0	1		–	284.9	9
Mykolayiv Region	4604.4	46	–	–	–	–	4604.4	46
Odesa Region	10755.4	94	520	4	–	–	11275.4	98
Poltava Region	9091.4	40	2322.4	12	84	7	11497.8	59
Rivne Region	–	–	–	–	–	–	–	–
Sumy Region	900.1	14	303.3	4	-	-	1203.4	18
Ternopil Region	957.2	11	17188.7	43	199.0	9	18145.9	54
Kharkiv Region	17309.1	84	106	3	–	–	17415.1	87
Kherson Region	3625.5	42	90.9	2	–	–	3716.4	44
Khmelnytsky Region	849.6	14	8351.6	33	11.0	3	9201.2	47
Cherkasy Region	3675.0	32	94.5	11	10.5	5	3780	41
Chernivtsi Region	–	–	–	–	–	–	–	–
Chernihiv Region	1129	13	–	–	–	–	1129	13
Total in Ukraine	73266.4	266	39218.1	103	617.16	33	112140.7	369

Source: calculated by the author based on ITC data [32]

The total demand of agricultural producers for winter wheat seeds is 1.5-1.6 million tons. If we assume that only two thirds of the produced conditioned seeds are sold (average percentage of sales of conditioned seeds by research institutions of NAAS), it will be about 92 thousand tons (5.8% of total demand). On average in the European market, this share of conditioned seeds is about 50% [22].

The largest producers of conditioned seeds of national selection among the regions of Ukraine are Kharkiv (17.4 thousand tons), Dnipropetrovsk (11.6 thousand tons), Odesa (10.7 thousand tons), Poltava (9.4 thousand tons) and Kyiv (5.4 thousand tons) regions, foreign selection – Ternopil (16.2 thousand tons), Khmelnytsky (9.9 thousand tons), Kyiv (3.9 thousand tons) and Zaporizhia (3.3 thousand tons) area. The largest number of certified imported seeds in Kyiv region is 1.1 thousand tons (73% of the total volume of imported winter wheat seeds) [4].

Production of conditioned seeds in the regions is closely connected with the presence of scientific breeding centers of the National Academy of Agrarian Sciences. Thus, in the Kharkiv region there is the Institute of Plant Breeding named after V.Ya. Yuryev of the National Academy of Agrarian Sciences of Ukraine, in Dnipropetrovsk region – Institute of Grain Crops of the National Academy of Agrarian Sciences of Ukraine, in Odesa region – Breeding and Genetics Institute-National Center for Seed and Cultivar Investigation of the National Academy of Agrarian Sciences of Ukraine [23].

The most productive varieties of winter wheat in recent years were Bohdana, Novosmuglyanka, Astarta, Zhytnytsia Odesa, Katrusya Odesa, Zysk, which exceeded the yield of 10 t/ha and more [4]. They were produced by the Institute of Plant Physiology and Genetics of the National Academy of Sciences of Ukraine (Kyiv) and the Breeding and Genetics Institute – National

Center for Seed and Cultivar Investigation of NAAS (Odesa).

Of the Ukrainian hybrids, the best sold in 2021 were: Bohdana (7707 tons), Podolyanka (4697 tons) Astarta (2064 tons), Sofia Kyivska (1867 tons), Novosmuglyanka (1231 tons), producer – Institute of Plant Physiology and Genetics of the National Academy Sciences of Ukraine; Wisdom of Odesa (4011 tons), Katrusya of Odesa (2338 tons), League of Odesa (1658 tons), Oranta of Odesa (1657 tons), Zysk (1401 tons), producer – Breeding and Genetics Institute – National Center for Seed and Cultivar Investigation of NAAS of Ukraine; Landscape (1658 tons), producer – National Research Center "Institute of Agriculture of the National Academy of Agrarian Sciences"; Shestopalivka (1638 tons), producer – Private Agricultural Breeding and Research Enterprise "BOR" [24].

The most common varieties of winter wheat for sowing in 2022 were also such foreign varieties as RZHT Reform, Kubus, Skagen, Colonia, KVS Jersey, Mescal, Praktik, Rebel, Bonanza and Felix. These varieties account for a significant share of Ukrainian agricultural production, which is growing dynamically. The main foreign companies operating in the Ukrainian seed market are: RAJT 2n (France), Nickerson International Research SNA (France), Zaaten Union Romania Srl. (Romania), Seyet Planteforledling I/S (Denmark), Nordic Sid A/S (Denmark), Deutsche Zaatferedelung AG (Germany) and Zaatsucht Donau Hes.m.b.H. & CoCG (Austria). French, Czech, German, Danish and Austrian selections are represented in Ukraine [4].

In total, in Ukraine, according to the State Register of Plant Varieties [4] suitable for distribution in Ukraine, 583 varieties of durum and soft winter wheat, 79 varieties of winter barley, 55 varieties of winter rye and 51 varieties of winter triticale (Table 2).

Table 2. Number of winter grain varieties used for additional seed production for the 2022 harvest

Cultures	TOTAL VARIETIES			NAAS		
	Number of varieties in the register, total	Number of varieties in the production of pre-seed, total	The share of varieties in the production of pre-seed, %, total	Number of varieties in the register (applicant – NAAS institutions)	Number of varieties in pre-seed production (NAAS institutions)	The share of varieties of NAAS institutions in the production of pre-seed, %
Winter wheat	583	188	32.2	338	97	28.7
Winter barley	79	14	17.7	29	5	17.2
Winter wheat	55	3	5.5	34	3	8.8
Winter triticale	51	17	33.3	37	14	37.8
Total	768	222	28.9	438	119	27.2

Source: calculated by the author based on ITC data [32]

The number of varieties used for the production of additional seeds for winter wheat is 32.2%, for winter triticale – 33.3%, for winter barley – 17.7%, and for winter rye – the least, only 5.5%. A low percentage indicates that not all varieties registered in the Register of Plant Varieties [19] are primary seed production. This is explained by both the demand for this type of product and its commercialisation. There are "still-born varieties" that are only produced for "demonstration" activities of enterprises or institutions, also, there are varieties that are 15-20 years old or more, and they are only maintained in the Register by paying the relevant payments (for Ukrainian breeding public institutions, they are not significant – 20-50 UAH per year). It should also be considered that primary seed production of foreign varieties is primarily carried out in their countries of origin, and basic seeds (super-elite and elite) and certified of different generations are already imported to Ukraine (Fig. 1).

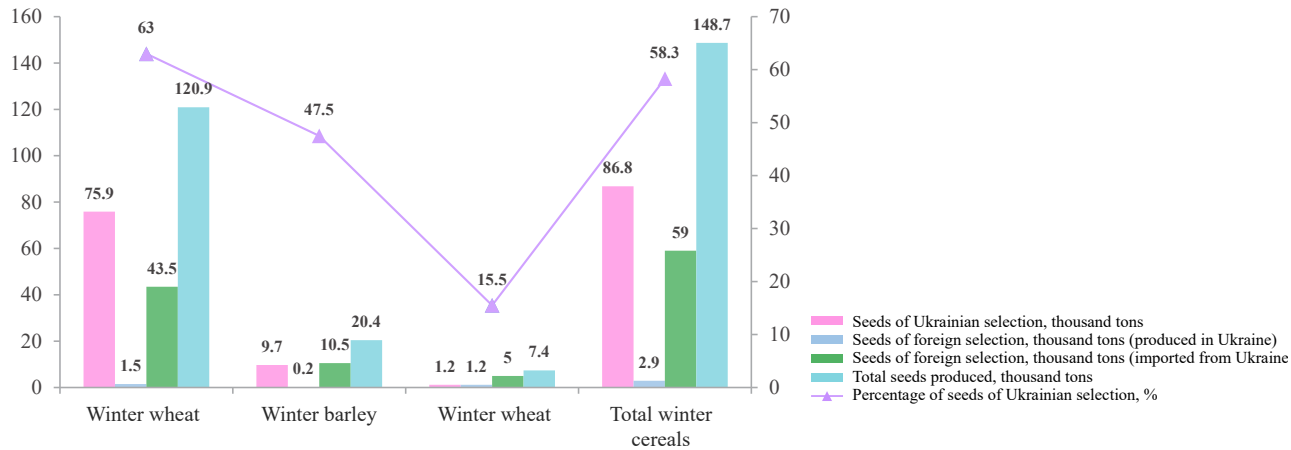

Figure 1. Production of conditioned seeds of winter cereals in Ukraine in 2021 (additional, basic and certified)
Source: calculated by the author based on ITC data [4]

The share of Ukrainian seeds in the total volume of winter grain seeds was 58.3%, including 63% for winter wheat, 47.5% for barley and 15.5% for rye. Seeds are a commodity of production demand from seed farms, which lead to its reproduction, and from direct producers, who use it as a resource in production. To study the demand for varietal seed resources, we first analysed the average annual demand, namely its material component – the seeds of winter cereals for all categories of farms.

To ensure the demand for varieties and seeds of winter cereals, it is estimated that 1.4-1.6 million tons of wheat seeds, 122.0 thousand tons of barley, 36.0 thousand tons of rye, and 10 thousand tons of triticale are needed (Table 3). The annual amount of varietal seed material required for sowing winter cereals in volumes not less than in the context of the regions of our state is calculated according to the sown areas of these crops.

Table 3. Average annual need for seeds of winter cereals

No.	Region	Sowing area in 2021, thousand hectares	The need for all, thousands of tons	Including:			
				Wheat	Barley	Rye	Triticale
1	Vinnytsia	324.3	84.3	72.7	8.8	2.0	0.8
2	Volyn Region	183.8	31.1	27.5	0	3.1	0.5
3	Dnipropetrovsk Region	677.2	133.2	119.9	13	0.3	0
4	Donetsk Region	396.8	89.1	82.5	4.6	1.0	1.0
5	Zhytomyr Region	154.7	29.8	24.4	0.2	5.2	0
6	Zakarpattia Region	24.4	6.4	4.4	2	0	0
7	Zaporizhzhya Region	795.1	132.5	125.5	6.8	0.2	0
8	Ivano-Frankivsk Region	51.1	11.6	10.3	0.8	0.5	0
9	Kyiv Region	209.1	60.5	58.0	0.4	1.6	0.5
10	Kirovograd Region	469.2	83.3	70.8	12.2	0.3	0
11	Luhansk Region	308.9	57.8	56.3	0.4	0.6	0.5
12	Lviv Region	172.5	32.1	28.9	1.2	2.0	0
13	Mykolayiv Region	703.0	135.6	114.8	20.6	0.2	0
14	Odesa Region	836.2	159.1	130.3	28.4	0.4	0
15	Poltava Region	256.3	60.7	58.1	1.6	1.0	0
16	Rivne Region	134.0	25.0	21.8	0.2	2.7	0.3
17	Sumy Region	182.9	40.1	37.5	0	1.8	0.8
18	Ternopil Region	201.7	41.8	38.7	1.6	1.5	0
19	Kharkiv Region	599.0	106.2	100.1	0.6	0.6	4.9
20	Kherson Region	613.2	113.7	101.9	11.2	0.6	0
21	Khmelnytsky Region	207.0	45.6	40.5	2.4	2.5	0.2
22	Cherkasy Region	234.4	58.9	56.1	1.8	1.0	0
23	Chernivtsi Region	36.7	10.3	7.9	2.2	0.2	0
24	Chernihiv Region	201.3	43.7	35.5	1	6.6	0.6
	TOTAL	7972.8	1592.4	1424.4	122.0	35.9	10.1

Source: calculated by sources [12; 25]

The national seed market can be described as fairly balanced, although at the beginning of the millennium it was an oversaturated market, the share of the final balance before consumption was almost 50% [22]. The reason for this was the low purchasing power of agricultural producers in the market of conditioned seeds and the possibility of one-time purchase of certified seeds with its subsequent long-term use without renewal, 5-8 years).

M. Suchek [26] also insists on the need for varietal replacement and varietal renewal. He also claims that the energy of the variety works on yields only for the first three years. Because only conditioned upon genetic potential it is possible to increase yields by 1-2 t/ha.

To stimulate demand in the seed market, efforts should be made to support the demand of Ukrainian grain producers for high-category seeds, as the condition of sown seeds has not deteriorated in recent years. At the same time, the yield of each subsequent reproduction decreases on average from 0.5 to 1.5 t/ha per year [26].

Therefore, it would be positive to improve the demand of the final consumer of grain seeds, the implementation of state programs for the formation of varietal plant resources and selection in crop production, including selection in primary crop, which operated in Ukraine until 2012. Positive was the partial reimbursement of agricultural producers of varietal allowances for purchased conditioned seeds in

research institutions, research farms of universities, which was carried out within the funds allocated from the state budget for these purposes, which is currently canceled.

Author's research on the financing of state programmes, in the main ideas coincide with the opinion of V. Kyrychenko – Director of the Institute of Plant Breeding named after V.Ya. Yuryev of the NAAS of Ukraine [27]. He claims that without financial support, breeders are left alone with their initiatives and achievements. Because the innovative development of any industry requires high-level state support. He agrees with us that seed production in Ukraine can be revived by funding NAAS research institutions on a competitive basis; modernisation and updating of the material and technical base of scientific institutions and networks; improvement of legal aspects of NAAS research institutions and their harmonisation with European standards on the basis of public-private partnership – resumption of the programme of state support for the production of high-generation seeds and creation and storage of seed funds on a competitive and transparent basis; adaptation of the seed industry of Ukraine to the relevant world requirements for seed production and certification, accession to all OECD seed schemes; strengthening the export potential of Ukrainian seeds by increasing its competitiveness in terms of quality, and eliminating bureaucratic barriers to seed access to the international market; systematic varietal renewal and varietal change, using seeds of exceptionally high generations, F1 hybrids and first and second generation in self-pollinating crops.

The study of varietal crops shows that varietal resources in agricultural enterprises are mainly formed based on own reproductive seed production and commercial crops. Conditioned seed production in all crops is only from 5% to 8%, respectively [3]. In general, it occupies about 10.0-12.0% of varietal crops of all crops in Ukraine. But in terms of crops, this percentage differs [13].

With limited domestic demand for grain seeds, it would be important to develop aggregate export demand at the expense of foreign consumers of Ukrainian seeds. However, the opportunities for Ukrainian seed market operators to enter foreign markets are limited conditioned upon:

– low awareness and financial capacity of breeders to transfer their varieties for testing to potential foreign consumers;
– non-membership in or membership in a number of international trade organisations;
– non-compliance with accepted European and world quality standards for certification;
– low solvency of potential consumers of seeds in the CIS countries, which are the primary potential buyers;
– weak marketing of foreign markets, especially European and North American.

However, the limited possibilities do not mean the absolute futility of their search. Ukraine has always been a supplier of conditioned seeds to regions of the Soviet Union that had less favourable conditions for its production. The payment crisis, the construction of new borders and expert duties have significantly affected agricultural producers of all newly formed states, and have sharply limited the possibility of Ukrainian seed exports. Those countries that have more developed systems of breeding and seed production, in 25-30 years, gradually abandoned imports and switched to self-sufficiency of their own seeds.

In the future, it is also possible to resume the export of Ukrainian seed material to the countries of Central Asia and North Africa, where there is a significant potential market capacity and liberal trade rules. Ukraine can take a leading place in this field. Cereal seeds (wheat, barley, rye, buckwheat and millet) are especially popular in the Asian and North African markets.

All developed countries finance from the budget basic research as the most expensive. Private breeding establishments compete to improve the discovery, usually only after a fundamental study has been done. This is especially true for the process of breeding new varieties and hybrids. In most western countries, only a breeder has the right to reproduce and sell conditioned seeds. This contributes to the intensification of seed production and its civilized market circulation. And government support, protection of plant variety rights and royalties provide an opportunity to conduct research and accelerate the supply of new innovative varieties and hybrids to the market.

The lack of construction of a similar system in Ukraine in the near future will lead to a loss of priorities, chronic backwardness of the breeding industry and further dominance of foreign breeding varieties. Given the limited budget funding, the introduction of a system for collecting royalties and selection payments and their 100% payment by agricultural producers may support the protection of the interests of breeding centers and breeders in Ukraine.

The main tasks of Ukrainian breeding science for the revival of Ukrainian breeding in 2022 should be: improving the technical and technological support of breeders and agricultural producers, developing recommendations for modern technologies for growing agricultural products in different climatic zones of the country; improving the legal aspects of the activities of research institutions of NAAS and NAS based on public-private partnership; adaptation of the seed industry of Ukraine to the relevant world requirements for seed production and certification, accession to all OECD seed schemes; strengthening the export potential of Ukrainian seeds of national selection by increasing its competitiveness in terms of quality, and eliminating bureaucratic barriers to entry of seed products on the international market.

Eight OECD Seed Schemes have been identified according to the groups of cultivated plant species: Grasses and Legumes scheme, Crucifers and other Oil or Fibre species scheme, Cereals scheme, Sugar and Fodder Beet scheme, Subterranean clover and similar species scheme, Maize scheme, Sorghum scheme, Vegetable scheme. They set out the requirements for the propagation of basic and certified seeds, approved as satisfactory for varietal identity and purity. They are applied at the official level and cannot be lower than those set by each Scheme [28].

By participating in Schemes for the Varietal Certification of Seed, seed operators can produce

and certify seeds of these crops in accordance with international standards and participate in world seed trade using OECD labels and certificates recognised by 60 OECD member countries. OECD certification is used for varieties that meet the requirements of DUS (difference, uniformity and stability). In this way, schemes during the process of propagation, processing, etc. ensure the preservation of purity and originality of the variety. Each Scheme includes a number of Rules and Regulations aimed at ensuring varietal certification of seeds, except for the Vegetables scheme, according to which seeds defined as "Standard Seeds" in general trade cannot be certified, but may only to be controlled, in particular: requirements for the production of basic and certified seeds in accordance with the Seed Schemes; field inspection of seed crops; seed batch size; marking and issuance of single varietal documents recognised by 60 countries participating in the OECD Seed Schemes [28].

In Ukraine, at the time of creation of new scientific and innovative centers for propagation of conditioned seeds in different regions of the country based on already established seed plants, introduce mandatory declaration of varietal crops by agricultural producers who own agricultural land of 25 hectares and more, increase the role professional public organisations of Ukraine in terms of registration of license agreements and royalty payments, including control, registration and introduction of the database of seed and commodity crops in terms of varieties and hybrids.

▸ Conclusions

The research presented in the article shows that despite the strategic importance of the seed industry in Ukraine, it has accumulated a number of problems. The main problem is the dominance of foreign varieties. Although Ukrainian varieties are better adapted to the natural and climatic conditions of Ukraine, the share of additional seeds of Ukrainian winter grain selection is less than 60% more resistant to drought and germination. The advantages of foreign varieties are higher yields, resistance to diseases and pests, transportability and appearance of marketable products. The share of varieties of scientific institutions of NAAS of Ukraine, which are engaged in additional seed production is only 28.7% – for winter wheat, 17.2% – for winter barley, 8.8% – for rye and 37.8% – for triticale.

The average annual need for winter grain seeds was determined according to the sown areas by regions and in Ukraine as a whole. In total, it is 1.4 million tons of wheat, 122 thousand tons of barley, 35.9 thousand tons of rye and 10.1 thousand tons of triticale.

Demand for seeds is determined by the purchasing power of Ukrainian agricultural producers. Today, varietal crops are formed mainly conditioned upon their own reproductive seed production from commercial crops. The share of used conditioned seeds is only 5-8 %.

In conditions of limited domestic demand for seeds of Ukrainian selection, it is important to develop external. Potential buyers of grain seeds are from Asia and North Africa.

Given a number of problems that have accumulated in the industry, the task for Ukrainian breeding science for 2022 has been identified. The results of their implementation are aimed at: improving the material and technical base of breeding institutions, especially those belonging to NAAS. It provides for the acquisition by research institutions of new, modernisation of existing small breeding and seed processing equipment, devices and equipment; improving the legal norms for the payment of royalties and selection payments, considering the experience of their use in the world, which could be directed to the development of the industry; adaptation of modern technologies to their use in different natural and climatic zones; adaptation of the seed industry to the world requirements for seed production and certification and accession to the OESD. This will open great prospects for Ukrainian seed exporters on the world market and strengthen Ukraine's export potential.

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Насінництво озимих зернових культур – основа діяльності національної селекції та завдання української селекційної науки у 2022 році

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► **Анотація.** Стратегічне значення зерна як товару на внутрішньому ринку та основного експортного сільськогосподарського товару визначає актуальність дослідження. На сьогодні проблема виробництва високоякісного насіння в Україні загострилася, адже недостатнє фінансування галузі, застаріла матеріально-технічна база селекційних організацій, мізерність роялтних та відсутність селекційних платежів ставить під загрозу розвиток українського насінництва. Динамічний розвиток галузі вимагає більш активної та зваженої політики в галузі, яка включала б державні цільові програми та розвиток нормативно-правової бази в частині забезпечення законних та прозорих прав на інтелектуальну власність селекціонерам та селекційним установам. Мета статті – проаналізувати та надати оцінку стану насінництва озимих зернових культур й визначити завдання української селекційної науки на 2022 рік. У процесі дослідження використано такі методи: діалектичний, системний підхід, монографічний, економіко-статистичний, табличний, графічний, емпіричний, порівняльний аналіз, абстрактно-логічний, аналітичне прогнозування. Досліджено стан насінництва озимих зернових культур і виявлено, що в Україні 583 сорти пшениці, 79 – ячменю, 55 – жита та 51 – тритикале. Виробництво добазового насіння здійснюється лише по 32 % сортів пшениці, 33,3 % – тритикале, 17,7 % ячменю та 5,5 % жита. З них українське становить лише 58,3 % по пшениці, 47,5 % – по ячменю та 15,5 % – по житу; визначено середньорічну потребу в насінні озимих зернових по регіонах України та в цілому по країні. Для забезпечення посіву зернових в обсягах, не менших посівних площ необхідно 1,4-1,6 млн т. пшениці, 122 тис. т. ячменю, 36 тис. т. жита та 10 тис. т. тритикале; сформовано завдання для української селекційної науки щодо розвитку насінництва озимих зернових культур на 2022 рік, які сприятимуть техніко-технологічному забезпеченню селекціонерів та виробників насіння, гармонізації та адаптації насіннєвої галузі України до світових стандартів, підвищенню конкурентоспроможності та збільшенню експортного потенціалу українського насінництва

► **Ключові слова:** зерновиробництво, кондиційне насіння, селекція, ринок, сорт, система насінництва, добазове та базове насінництво

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Prospects for Increasing the Level of Innovation Activity of Dairy Enterprises

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► **Abstract.** Progressive development of the dairy industry requires improving technologies of feed production, keeping, feeding, increasing livestock and breeding work on farms, the genetic potential of breeds, milking cows, storing and processing milk and producing the necessary range of dairy products. Successful implementation of these technological processes requires an effective system of innovative support for dairy production, for which the scientific developments of the National Academy of Agrarian Sciences of Ukraine are important. At the same time, the ability of dairy enterprises to innovative development is determined by the transformation of their economic mechanism through the introduction of technical, organisational and managerial achievements in the field of technology. The purpose of the article is to study the current realities, opportunities and forecast the main dimensions for the intensification of innovative activities of dairy enterprises in Ukraine. A number of methods were used in the research process: monographic; comparative analysis; prognostication; tabular; settlement and constructive; graphic, abstract-logical. The existence of an adapted system of innovative support is established and scientific developments of control in the selection of raw milk, vitamin naturalisation of milk, technologies of production of dietary dairy products, automation of production processes, heat treatment of milk using modern packaging materials to extend its shelf life, introduction of innovative methods in operational activities, personnel development, marketing and logistics, the use of which should be extended in the system of economic mechanism of functioning and development of the dairy industry. The forecast indicators of the raw material base of the dairy industry of Ukraine, which in 2025 will remain at the level of 2020 and will amount to 9287 thousand tons, with an increase in milk production in agricultural enterprises by 13.0% and a decrease in households by 5.0%. The necessary volumes of raw material production have been established to ensure the production capacity of milk processing enterprises and the rational norm of consumption of milk and dairy products. The dynamics of forecast indicators of dairy production in Ukraine is constructed. The priority target guidelines of the strategy of intensification of innovative activity of milk processing enterprises are substantiated. An algorithm for increasing the innovative activity of a processing enterprise is proposed. These approaches and research results can be used by public and sectoral authorities in the organization of monitoring and development of priority measures to intensify the innovative activities of Ukrainian dairy industry

► **Keywords:** milk, dairy products, innovations, production, processing

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Introduction

It is possible to provide the population with dairy products only under the condition of stable and balanced development of the market of milk and products of its processing. The functioning of the dairy market affects the state of production, the development of market infrastructure, the effectiveness of market mechanisms, innovative processes of development of the dairy industry. Increasing raw milk for the dairy industry and quality dairy products for the population requires a radical technological restructuring of the industry. However, dairies with different depths of processing of raw materials and structure of final products have different opportunities for the implementation of innovative projects. With a low level of milk processing and a lack of own funds, small and medium-sized enterprises are left with the function of warehouses for the movement and storage of raw milk. An important task is the modernisation and rational use of production capacity of dairy enterprises.

The concept of innovation and its features in the dairy industry are considered in the works of Ukrainian and foreign scientists. The essence and features of innovative technologies in dairy farming are studied by I.I. Cherven [1], J. Shudlurski, S. Zaika, O. Gridin [2], P. Putsenteilo, V. Nyanko, V. Karpenko [3]. The authors of the publications prove that innovative activity in the conditions of rapid development of the competitive environment and unstable positions of the dairy industry is the foundation for ensuring the profitability of milk production. State policy in the dairy sector should be aimed at supporting research into innovative technological processes and their large-scale development. The experience of introducing innovative approaches in the dairy industry shows the high efficiency of knowledge-intensive and research innovations. The use of innovative technologies and innovative principles of production management is the key to bringing the dairy industry out of the pre-crisis state. On the modern problems of development of the dairy industry focused their research V.L. Karpenko [4], V.M. Tsikhanovskaya [5], W.W. Jejula [6], S. Shupyk [7].

O. Petrichenko outlines the issues of innovation and investment support of the raw material base of the dairy industry, introduction of scientific developments, state support of the dairy industry, investments to increase milk production. It is established that the decrease in innovation activity of enterprises does not correlate with the dynamics of investment processes, which indicates a weak innovation orientation of investment and leads to the accumulation of physically and morally obsolete equipment [8]. Management of technological development of the dairy industry is developed by A. Fenenko [9]. A. Shust, A. Varchenko, and I. Paska take care of the substantiation of the strategy of innovative development of milk production enterprises [10]. Innovative factors and prospects for increasing the competitiveness of the dairy industry are studied by O. Kruglyak [11], M. Parkhomets, L. Uniyat [12], O. Stets [13]. Some aspects of increasing the level of intensification during milk production are considered by V. Kolosha [14], V. Radko [15] D. Simo, L. Mura, J. Buleca [16], V. Maciuc, M. Şteofil, V. Domnica and others [17]. M.I. Ulla highlights the increase of innovation potential on dairy farms through the exchange of knowledge; B.A. Hamid, Kamal; A. Shahzad; Mahmoud, Zeeshan. The authors hypothesised that trust, motivation, training and development are related to the exchange of knowledge between employees and managers and have a positive impact on the innovative capacity of dairy farms [18]. Stimulating the small dairy market and improving livestock feed through local innovation platforms T. Ravichandran, N. Teufel, F. Capezzone, R. Birner, A.J. Duncan. Scientists have studied the changes in small-scale production and marketing of dairy products conditioned upon the creation of a series of innovative platforms. The links between the processes and results of the innovation platform, the use of systematic documentation of results and the identification of factors of influence [19]. Determinants of sustainable innovation of small dairy farmers are set by S. Chindime, P. Kibwika, M. Chagunda, P. Gonzalez-Redondo who proved that for effective and sustainable innovation management, a clear policy should be put in place to provide formal structures to maintain innovation continuity through improved social networks between farmers and cost-effective mechanisms for accessing quality resources [20].

Methodological and practical aspects of a comprehensive study of the state and substantiation of prospects for increasing the level of innovation activity of dairy enterprises have been further developed.

Materials and Methods

Comprehensive and in-depth study of innovative processes in the dairy industry to detail the current level of innovative tools and the choice of promising areas for improvement of milk production and processing technologies was conducted using the monographic method. Comparison of actual and projected indicators of livestock and productivity of cows and milk production in agricultural enterprises and households and production of dairy products in the range was carried out based on collected statistical and forecast data by comparative analysis. A tabular method was used to visualise the results of the study. Determination of forecast indicators of raw material production to ensure a rational consumption of milk and dairy products was carried out by the calculation and design method. The construction of the algorithm for increasing the innovative activity of the dairy processing plant was carried out by the graphical method. The conclusions are formulated by the abstract-logical method.

To determine the forecast indicators of the development of the raw material base of the dairy industry and substantiate the prospective measurements of dairy production by Ukrainian processing enterprises until 2025, forecasting tools using trend extrapolation were used. The methodology of the study can be structured as the following algorithm.

1. The forecast of the theoretical number of cows in agricultural enterprises is built on a logarithmic trend using the formula (1):

$$y = a\ln(x) + b \quad (1)$$

where y is the projected value of the cow population in agricultural enterprises; a and b are constants.

2. The forecast of the theoretical number of cows in households and the inflow of milk to processing enterprises from commodity farms is built on an exponential trend using the formula (2):

$$y = ae^{bx} \quad (2)$$

where y is the forecast values of the number of cows in households and the amount of milk received by processing enterprises from commodity farms; a and b are constants, e is the basis of the natural logarithm.

3. Equalisation of actual indicators of dynamics and development of the forecast of levels of productivity of cows in agricultural enterprises and households, and also the forecast of theoretical receipt of milk on processing enterprises from agricultural enterprises is carried out by means of polynomial function with use of the formula (3):

$$y = a_0 + a_1x + a_2x^2 + \ldots + a_nx^n \text{ for } n\leq 6 \quad (3)$$

where a_0, a_1, a_2, ... a_n are constants.

It should be noted that the polynomial trend of the second degree was used for these forecasts during the study.

$$y = a_1x^2 + a_2x + a_3 \quad (4)$$

where y – projected values of productivity of cows in agricultural enterprises, households and milk supply to processing enterprises from agricultural enterprises; and_1, and_2, and_3 – calculated coefficients.

4. The following systematised tools for trend approximation were used to develop forecast parameters of natural volumes of dairy production in Ukraine (Table 1).

Table 1. Methodical tools for calculating the forecast parameters of dairy production in Ukraine

Type of dairy products	Type of trend approximation	Modeling formula
Processed liquid milk	polynomial of the 2nd degree	$y=a_1 \cdot x^2+a_2 \cdot x+a_3$
Milk (and cream) for baby food is condensed and sugar-free	Stagnant	$y=ax^b$
Milk and cream with a fat content of more than 6%	Stagnant	$y=ax^b$
Milk and cream dry	Exponential	$y=ae^{bx}$
Butter	Polynomial of the 3rd degree	$y = a_1 \cdot x^3+a_2 \cdot x^2+a_3 \cdot x+a_4$
Fresh unfermented cheese	Logarithmic	$y=aln(x)+b$
Sour milk cheese and baby food products	Linear	$y=ax+b$
Rennet cheeses	Stagnant	$y=ax^b$
Cream cheese	Polynomial of the 2nd degree	$y=a_1 \cdot x^2+a_2 \cdot x+a_3$
Milk and cream, condensed or with added sugar	Polynomial of the 2nd degree	$y=a_1 \cdot x^2+a_2 \cdot x+a_3$
Yogurt, kefir, sour cream	Polynomial of the 2nd degree	$y=a_1 \cdot x^2+a_2 \cdot x+a_3$
Fermented milk products for baby food	Exponential	$y=ae^{bx}$

Source: formed based on the results of the author's own research

The empirical basis of the study consists of reports of the National Academy of Agrarian Sciences of Ukraine, statistical materials and official websites of enterprises of milk processing companies of Ukraine.

▸ Results and Discussion

Ensuring a purposeful vector of progressive development of the dairy industry should be considered as a comprehensive, traceable at each stage and systemically interdependent algorithm. Thus, the priority areas of development of dairy enterprises and the industry in general focus on the following areas, taking into account the sequence of the organisational and technological chain. It includes the development of selection and breeding work on farms, increasing the genetic potential of breeds, increasing the number of livestock; improvement of technologies for growing, keeping, feeding and milking cows; improvement of milk storage and processing technologies; introduction of innovative technologies of milk production.

Successful implementation of these technological processes requires an adapted system of innovation.

In the process of research the most thorough scientific developments are systematised, the use of which should be spread in the system of economic mechanism of functioning and development of the dairy industry (Table 2).

Table 2. Innovative tools for the development of the dairy industry of Ukraine

No. s/n	Directions for improving milk storage and processing technologies
1	The method of selection of raw milk for the production of sour milk cheese on the basis of its quality by introducing enzyme preparations at a temperature of 35°C and determining the clotting time of milk in minutes. The rawness of raw milk is preliminarily assessed by its quality and safety – somatic cell content and bacterial contamination, which increases the selection of raw milk for the production of sour milk cheese, using milk-containing enzyme preparations (MEP) of plant or microbial origin
2	The method of vitamin naturalisation of functional milk is to include in the main diet of lactating cows a premix, which additionally introduces vitamin E in the amount of 490 mg/live/day, which allows to increase the concentration of vitamin E in milk to 0.245-0.05 mg/100 g, and reduce the number of somatic cells to 500 thousand/cm^3 , which meets the requirements of first grade milk. The claimed method is cost-effective and simple in technical implementation and production conditions
3	Technology of production of low-lactose fermented milk products for children and adults. The technical conditions apply to the production of fermented milk products, which are produced from normalized milk mixture of milk and demineralised whey obtained by nanofiltration with a demineralization level of 30% and above, in which lactose is partially hydrolysed (broken down into glucose and galactose) by lactase made on pure crops. The technology saves up to 50% of whole milk through the use of liquid or reconstituted demineralised whey
4	Technology of production of sour-milk product «Vitalakt» for special dietary baby food. The technology of fermented milk product has been developed, the functional orientation of which is conditioned upon the presence of probiotic microflora, which contributes to the positive impact on the gastrointestinal tract of the child and allows to recommend it for feeding children of early, preschool and school age. The technology has no world analogues
5	Technologies for the production of new types of cheese, which allows to ensure their high biological and nutritional value with guaranteed quality and safety. The technology allows to save up to 5% of raw milk conditioned upon the fuller use of milk components

Source: based on data [21-23]

The Institute of Food Resources of NAAS is actively working on a comprehensive solution to the problem of technological development of milk production, using modern advanced solutions and best practices in the dairy industry. Developed high-efficiency energy-saving equipment expands the range of its use in the manufacture of cheese, mayonnaise, pasta, butter and other fat-based products.

Thus, enterprises of Ukraine and other neighboring countries purchased more than 200 oil generators of the Ya5-OMS brand, emulsifiers of the Ya5-OEV series for the production of homogenized dairy and fat products and processed cheese. Innovative block-modular units for high-temperature pasteurization of Ya5-ORP cream and Ya5-OPS milk-fat mixtures provide stable and efficient heat treatment of viscous products and reduce energy costs by more than 3 times [21].

Automated installations of the Ya5-OMS-M brand for production of butter, spreads and margarine are a series of universal installations for production of all types of fatty products with fat content from 50 to 82% both with a liquid consistence with packing filling in big transport container, and with firm consistency followed by packing in the form of briquettes. The development is aimed at the production of new Ukrainian technological equipment for the production of oil and other fatty products, which improve production conditions and provide a significant increase in productivity. Results from the implementation: reduction of specific metal content by 5%, reduction of the area by 35, reduction of repair and maintenance costs by 15%, large effective heat transfer area. The equipment allows creating modern technological lines that improve production conditions and provide a significant increase in productivity. According to technical indicators, the equipment is not inferior to world analogues [22].

The development of an installation for pasteurisation of fat mixtures of spreads is aimed at intensifying pasteurisation processes and reducing their energy consumption. The determining factor was the new design of the pasteurizer and its hydrodynamic characteristics, which ensure minimal energy costs and stable and efficient pasteurisation. The economic feasibility of development focuses on reducing electricity costs by 2.5 times. To save heat resources in the stages of heating fat mixtures before pasteurisation, the regenerative heat of the pasteurised product is used. This saved up to 60% of thermal energy. This development has no world analogues [23].

The original design of 5-OSZh cheese makers and their cutting and mixing tools (mixers) allow increasing the yield of cheese grain by 3-5% with its high quality and minimum cheese dust content. The control system allows controlling the operation of the device in automatic, semi-automatic and manual control modes. The economic feasibility of development is to reduce raw material costs and increase the yield of the finished product by 3-5%, reduce the cost of thermal energy for production to 10% and electricity to 2%. Development at the level of world analogues [23].

The set of cheese-making farm of the Ya5-OKS brand is intended for production of all types of cheeses in the conditions of farm cheese-making shops with a capacity from 1000 to 3000 l of processing of milk a day. The development helps to reduce the cost of raw materials and increase the yield of

the finished product by 3-5%, reduce the cost of thermal energy for production up to 10% and electricity up to 2%.

The original design of the devices allows to increase the yield of cheese grain by 3-5% with its high quality and minimum cheese dust content. The control system allows controlling the operation of the device in automatic, semi-automatic and manual control modes. The level of development corresponds to the level of world analogues [22].

Thus, the scientific institutions of the National Academy of Agrarian Sciences of Ukraine provide innovative development of both the raw material base and the field of milk processing. Scientific developments and practical achievements are closely interconnected and allow influencing the processes of stabilisation and further development of the dairy industry. Systematic formation and strategic purposefulness of their use can create a positive synergetic effect.

At the same time, it is expedient to establish real prospects for the development of the raw materials industry in the current trends and optimistic forecasts.

To analyse the trend based on the time series of actual livestock, productivity of cows and milk supply to dairy enterprises in agricultural enterprises and households and build a forecast considering the patterns of the previous 16-year period (2006-2021), used dependence (trend equation) (5):

$$y = f(t) + \xi_t \quad (5)$$

where $f(t)$ – determined non-random component of the process (phenomenon); ξ_t – stochastic random component of the process.

Among the objective patterns for the period 2006-2021, which were established during the study and considered in the construction of forecast models, we systematically highlight:

– reduction of the number of cows in agricultural enterprises by 51.1% (from 624 to 424 thousand heads;

– reduction of the number of cows in households by 55% (from 2769 to 1249 thousand heads;

– increase in productivity of cows in agricultural enterprises in 2,4 times (from 2833 to 6796 kg);

– increase in productivity of cows in households by 1.3 times (from 3912 to 5120 kg);

– increase in milk supply to processing enterprises from agricultural enterprises by 1.5 times (from 1831 to 2726 thousand tons);

– reduction of almost 5 times the amount of milk received by processing enterprises from households (from 3393 to 733 thousand tons) [24]

In analytical alignment, the actual values are replaced by theoretical ones, calculated based on the function (trend equation), selected depending on the preliminary analysis of data dynamics (Figs. 1-6].

To assess the adequacy of each equation, which mathematically describes the actual trends and characterises the projected prospects, the author calculated the approximation coefficients (R^2), the value of which indicates higher accuracy and more reliable characteristics of the selected equation. According to the equations of the trend with the highest approximation coefficients, the forecast indicators of the raw material base of the dairy industry of Ukraine – milk production in agricultural enterprises and households for the period up to 2025 are determined (Table 3).

Table 3. The result of alignment by analytical functions

Indicator (factor)	Type of approximation	Forecast model	R^2
Livestock of cows			
S-g. of enterprises (Fig. 1)	Logarithmic	y=-149.9$Ln(t)$+860.37	0.9790
Households (Fig. 2)	Exponential	y=2815.8$e^{-0,048x}$	0.9824
Productivity of cows			
S-g. of enterprises (Fig. 3)	Polynomial	y=-4.3237x^2+352.3x+2266	0.9894
Households (Fig. 4)	Polynomial	y=3.8858x^2+11.126x+3946.8	0.9194
Receipts of milk to processing enterprises from:			
S-g. of enterprises (Fig. 5)	Polynomial	y=-3.7981x^2+140.92x+1443.9	0.8841
Households (Fig. 6)	Exponential	y=4362$e^{-0,1129x}$	0.9771

Source: compiled by the author.

Figures 1-6 contain visual results of equalisation by analytical functions, namely – actual, and by the established functional equations (Table 3) theoretical and forecast indicators of livestock, cow productivity and milk supply to dairy plants in Ukraine. All selected forecasting models are adequate and statistically significant, so they can be used to justify the stabilisation of the dairy industry and the prospects for the development of dairy enterprises in our country.

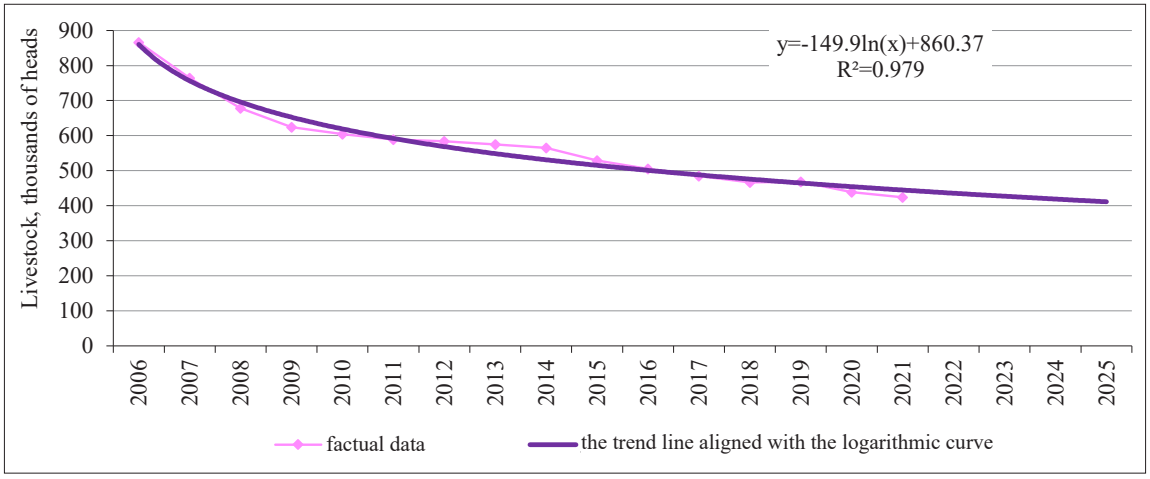

Figure 1. Dynamics of actual and forecast of theoretical livestock of cows in agricultural enterprises
Source: compiled by the author

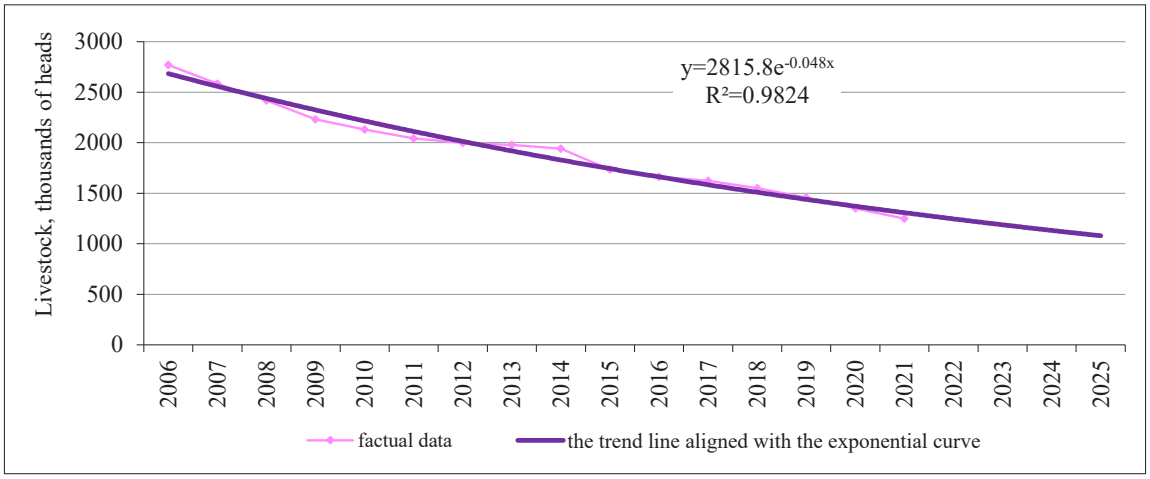

Figure 2. Dynamics of actual and forecast of theoretical livestock of cows in households
Source: compiled by the author

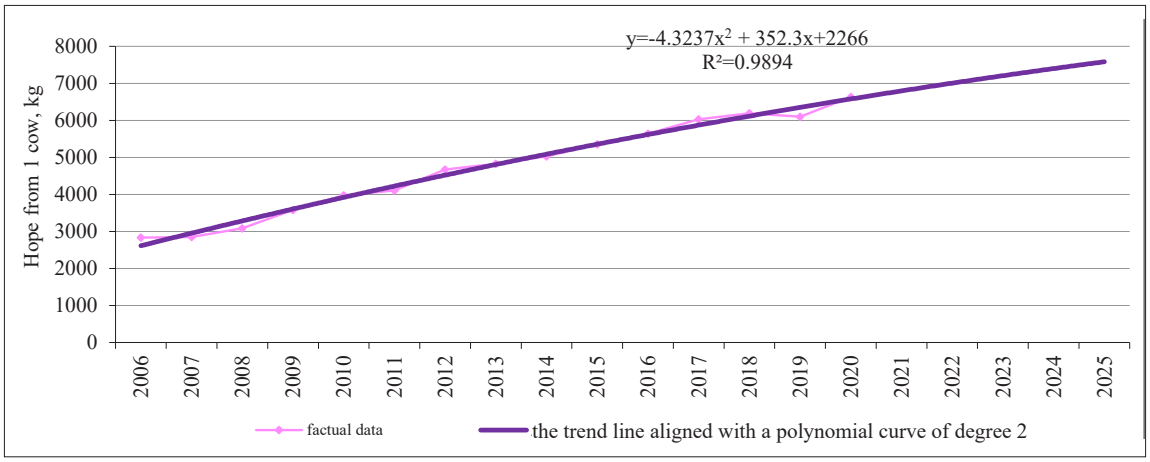

Figure 3. Dynamics of the actual and forecast of the theoretical level of productivity of cows in agricultural enterprises
Source: compiled by the author

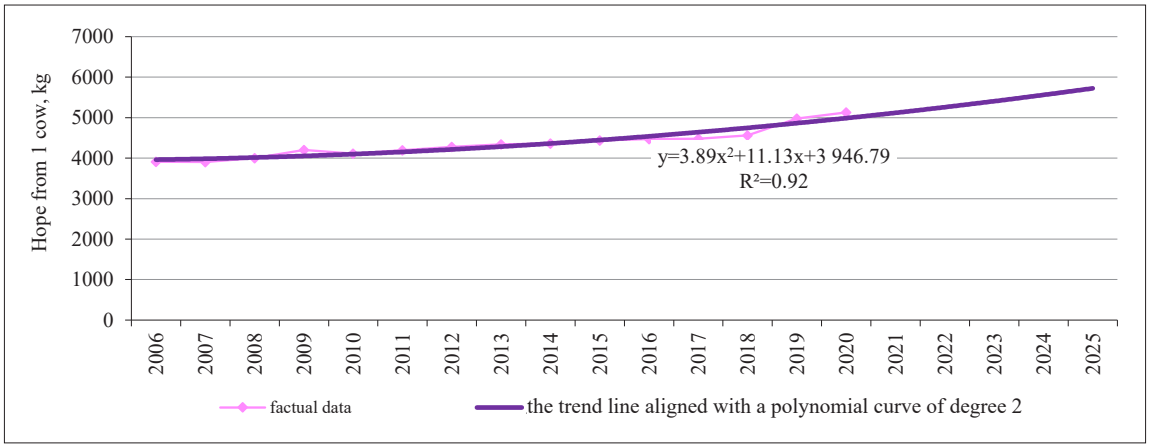

Figure 4. Dynamics of the actual and forecast of the theoretical level of productivity of cows in households
Source: compiled by the author

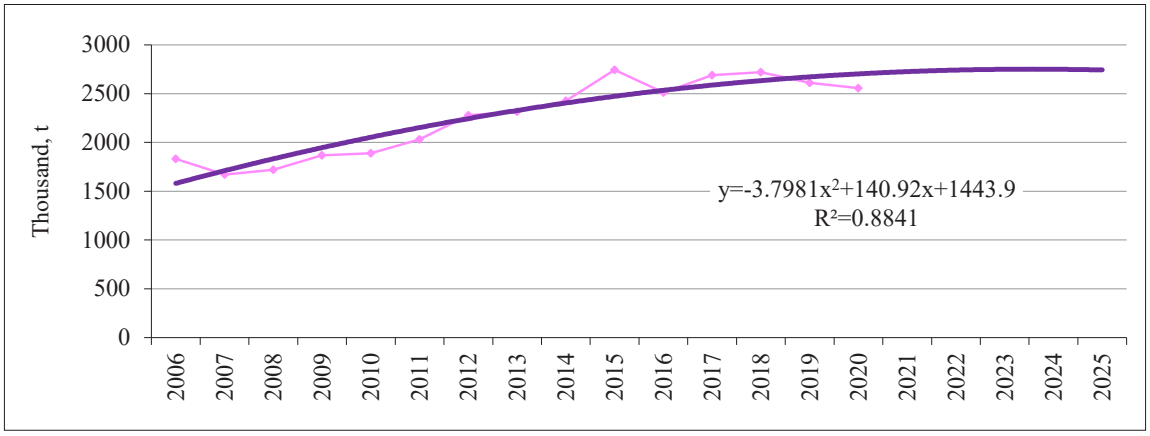

Figure 5. Dynamics of actual and forecast of theoretical milk supply to processing enterprises from agricultural enterprises
Source: compiled by the author

Figure 6. Dynamics of actual and forecast of theoretical milk supply to processing enterprises from commodity farms of the population
Source: compiled by the author

Trends identified in the forecasting process with a high degree of probability indicate a further reduction of 6.3% in livestock and an increase of 11.4% in productivity of cows in agricultural enterprises and a decrease of 21.1% in livestock and growth by 11.6% of productivity of cows in households.

At the same time, milk production in 2025 will remain at the level of 2020 and will amount to 9287 thousand tons, including 3117 thousand tons in agricultural enterprises with a growth trend of 13.0%, and in households – 6170 thousand tons while reducing its volume by 5.0%.

According to the UN, Ukraine is among the leaders in the rate of population decline in the world and is projected to decrease by 2050 to 35 million people [25]. According to the forecast of Ptoukha

Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine found that the population of the country in 2025 at medium, high and low birth rates, life expectancy and migration will be 43.7; 45.1 and 41.6 million people, respectively [26]. Given the developed two versions of the socio-demographic forecast for Ukraine using extrapolation of the trend and long-term calculations, the population in 2025 will be at 39.5 and 40.8 million people, respectively [27].

Milk production per capita will be 235 kg. With an average share of its consumption in recent years of 85% of production, the projected level of milk consumption per capita in 2025 will be 200 kg, or 51.2% of the rational norm of 390 kg. Considering the presence of the target orientation to achieve a rational level of consumption, the volume of milk production should be 18,124 thousand tons.

The supply of milk to processing enterprises from agricultural enterprises under the current trends will increase in the future from 2556 to 2743 thousand tons, or 7%. At the same time, its share in total production will decrease from 92.6 to 88.0%. The forecast of milk supply to processing enterprises from households due to its low quality indicates a negative trend of reduction from 733 to 570.6 thousand tons, or 22.2%, which will be 9.2% of the production level.

The presence of a tendency to reduce milk production in households implies the need to increase milk production by agricultural enterprises. The first scenario of achieving rational consumption of milk and products of processing enterprises involves a significant increase in production in agricultural enterprises due to a significant increase in the number of dairy herds, considering the gradual increase in its productivity.

Thus, according to estimates, by 2025 milk production should increase 4.6 times to 12,600,000 tons. Taking into account the projected level of productivity of cows in agricultural enterprises 7583 kg, the number of livestock should be increased 4 times, which in the current realities of state policy to restore dairy farming is almost unrealistic goal (Table 4).

Table 4. Forecast indicators of raw material production to ensure rational consumption of milk and dairy products

Indicators / Years	2021	2022	2023	2024	2025
Population, *million people*	41.4	40.7	40.3	39.9	39.5
Volume of milk consumption for the rational norm, thousand tons	16146	15873	15717	15561	15405
Milk production for the rational norm, *thousand tons*	18995	18674	18491	18307	18124
Scenario 1					
Required milk production, *thousand tons*	18995	18674	18491	18307	18124
including agricultural enterprises	12600	12127	12074	12018	11954
households	6395	6547	6417	6289	6170
Yield from 1 cow, kg					
All categories of farms	5176	5224	5307	5385	5449
agricultural enterprises	6796	7006	7207	7399	7583
households	5120	5259	5406	5561	5724
Livestock of cows, *thousand heads*					
All categories of farms	3103	2976	2862	2755	2654
agricultural enterprises	1854	1731	1675	1624	1576
households	1249	1245	1187	1131	1078
Scenario 2					
Livestock of cows, *thousand heads*	1697	1702	1653	1606	1563
including agricultural enterprises*	448	457	466	475	485
households	1249	1245	1187	1131	1078
Milk production, *thousand tons*					
All categories of farms	9439	9749	9776	9807	9848
including agricultural enterprises	3045	3201	3359	3518	3677
households	6395	6547	6417	6289	6170
Lack of milk consumption, *thousand tons*	9556	8925	8714	8500	8276
livestock, *thousand heads*	1406	1274	1209	1149	1091

Note: *Subject to an annual increase of 2%
Source: compiled by the author

The second scenario is based on the forecast trends in the productivity of cows in farms of all categories, including the reduction of cows in households from 1350 thousand heads in 2020 to 1078 thousand heads in 2025 with an annual increase in their number of 2% in agricultural enterprises. At the same time, the annual shortage of rational consumption of milk and dairy products will range from 9.6 million tons in 2021 to 8.3 million tons in 2025. The shortage of livestock will tend to decrease from 1406 thousand heads in 2021 to 1091 thousand heads in 2025.

According to the forecasted indicators of the

constructed trends of development of the raw material base of the Ukrainian dairy industry, it is expedient to provide and substantiate perspective tendencies of volumes and assortment structure of dairy production by processing enterprises of Ukraine.

It is estimated that the volume of production of such dairy products as butter in 2025 will not change significantly and will remain at the level of 2020. The increase in production is projected for the following types of products: yogurt, kefir, sour cream – by 37.6%, from 441.2 to 607.2 thousand tons; sour milk cheese and baby food products – by 36.3%, from 7.6 to 10.3 thousand tons, condensed milk and cream – by 30.1%, from 37.8 to 49.1 thousand tons, milk and cream with a fat content of more than 6% – by 19.7%, from 60.8 to 72.8 thousand tons; milk for baby food – by 18.3%, from 17.3 to 20.4 thousand tons; processed liquid milk – by 11.5%, from 105.3 to 117.2 thousand tons.

Relatively insignificant decrease in production of hard cheeses – by 7.8%, or 6.7 thousand tons, milk powder and cream – by 10.6%, which is 4.9 thousand tons, fresh unfermented cheese – by 11.2%, or 8.3 thousand tons, and fermented milk products for baby food – by 22.2%, or 0.9 thousand tons (Table 5).

Table 5. Dynamics of forecast parameters of dairy production in Ukraine, tons

Indicators	Fact 2020	Type of approximation	Forecast model	R^2	2021	2022	2023	2024	2025	2025 to 2020, %
Processed liquid milk	1053117	Polynomial	$y=1596.3x^2-6302.2x+947267$	0.4489	1043875	1071095	1101508	1135113	1171911	99.1
Milk (and cream) for baby food is condensed and sugar-free	17258	Stagnant	$y=10540x^{0.3022}$	0.7687	20102	20215	20257	20360	20414	118.3
Milk and cream with a fat content of more than 6%	60843	Stagnant	$y=39687x^{0.2304}$	0.6389	66540	68325	70843	71220	72839	119.7
Milk and cream dry	45668	Exponential	$y=68457e^{-0.04x}$	0.7947	46722	45582	44742	43638	40810	89.4
Butter	87455	Polynomial of the 3rd degree	$y=66.297x^3-1875\ x^2+13998\ x+76076$	0.5602	94813	91372	88556	86762	86389	98.8
Fresh unfermented cheese	73782	Logarithmic	$y=-5630Ln(t)+80367$	0.4778	67403	66867	66377	65926	65509	88.8
Sour milk cheese and baby food products	7576	Linear	$y=520.25x+3039.1$	0.8287	8241.6	8761.85	9282.1	9802.35	10322.6	136.3
Rennet cheeses	85230	Stagnant	$y=147208x-0.2592$	0.8556	84045	81348	80674	79325	78541	92.2
Cream cheese	30621	Polynomial	$y=-42{,}937x^2+1503.2x+20251$	0.9712	30989	31591	32106	32536	32880	107.4
Milk and cream, condensed or with added sugar	37765	Polynomial	$y=471.86x^2-8293.8x+72748$	0.9641	36996	38611	41170	44673	49119	130.1
Yogurt, kefir, sour cream	441205	Polynomial	$y=3652x^2-48010x+563532$	0.7717	448632	477314	513300	556590	607184	137.6
Fermented milk products for baby food	4006	Exponential	$y=6631{,}3e^{-0.0539x}$	0.6799	3868	3665	3473	3291	3118	77.8

Source: compiled by the author

Achieving stable and relatively progressive trends in the development of the Ukrainian dairy industry is possible in the case of increasing innovation activity of dairy enterprises. For example, Lustdorf uses innovative high-temperature pulse (UHT) technology in dairy production. Its essence is that for only 2-4 seconds the raw milk is subjected to a heat pulse at a temperature of 137°C, after which

it cools down to 25°C just as quickly. This advanced technology makes it possible to destroy all pathogenic bacteria and at the same time preserve the natural value of milk – protein, vitamins, trace elements [28].

Thanks to careful heat treatment, ultra-pasteurised dairy products can be stored in a closed package for up to six months. Another innovation used by Lustdorf in the preparation of raw materials for production is steam treatment. The technology assumes that steam is injected into raw milk under high pressure (4 bar), which instantly heats it to 140°C, and after a few seconds the milk is cooled to 20°C without contact with air and light. This gently cleanses the milk from foreign bacteria, while preserving its benefits and delicate pleasant taste without the taste of boiling [28].

Dairy enterprises of the Dairy Alliance group of companies have been gradually carrying out radical reconstruction and modernisation of production facilities in recent years. New shops for packing pasteurised milk and whole milk products are put into operation, cheese-making shops are equipped with modern equipment, where the production process is fully automated. Particular attention is paid to input control of raw materials, control over the technological process and output control of finished products. By equipping all reception points with new technological equipment for cooling and storage of milk, companies have managed to improve the qualitative and quantitative characteristics of raw materials for processing [29].

At the same time, the development of any enterprise has clearly defined specific features of implementation, which are mediated by the economic mechanism of increasing their economic efficiency. Each individual milk processing enterprise has an individual staffing and ratio of elements of resource potential that directly affect the competitiveness of enterprises and the pace of their development. Therefore, the development of a strategy to increase the level of innovation activity of the enterprise is aimed not only at maintaining its existing market position, but also by increasing the existing competitive advantage with the justification of a scientific approach to this phenomenon and process. The priority target guidelines of the strategy for intensifying the innovative activity of dairy enterprises are the following:

– development, substantiation and implementation in practice of measures to stabilise, expand and ensure the high quality of the Ukrainian raw material base and the creation of new raw material zones of the dairy industry;

– intensification of processes of wide introduction of innovations at the enterprises of agricultural milk producers for increase of production volumes;

– ensuring conditions of the most uniform, especially during the season, loading of production capacities of dairy processing enterprises;

– substantiation and effective implementation of the state policy on milk market regulation and investment support of the strategy of intensification of innovative activity not only of milk processing enterprises, but also of economic entities that form the raw material base of the dairy industry.

Intensification of innovative activity of enterprises in the industry will help increase productivity, quality of raw milk and a range of dairy products; efficiency of dairy farming and increasing the level of provision of dairy processing enterprises with quality raw materials; optimisation of purchasing price policy for milk; growth of production and supply of extra milk to processing enterprises; increasing the profitability of dairy enterprises.

At the same time, organisational and managerial innovations can become an important source of other types of innovative changes and growth of innovation activity, as the decision on the need for innovative transformations is made at the managerial level. The development of measures to increase the level of innovation activity of dairy enterprises requires a comprehensive analysis of all parts of the relationship between the participants of the system "milk production → milk processing → dairy sales" and their infrastructure links, which significantly affect the effectiveness of this marketing chain.

The essence of developing the concept of increasing the level of innovation activity of economic entities is to determine the innovation goal that can be achieved by a particular enterprise in view of its market position, innovation and resource capabilities. Based on the innovation goal the innovation strategy of the enterprise is formed, which should envisage combining the goals of technical and investment policy and be aimed at the introduction of new technologies and types of products, services and their promotion on the market. Thus, innovation is a leading link in strategic development management to achieve future market results to increase the competitiveness of dairy enterprises.

The key to the effectiveness of increasing the level of innovation activity of dairy enterprises should be the maximum reduction in the development of measures for the implementation of technical, technological and product innovations. Successful implementation of these tasks should be ensured by established, formalised and standardised measures for the development and implementation of strategies for innovation and production activities, which systematically cover the operating environment of the entity. These include its available resource-production and market potential, the results of monitoring of specific innovative developments and products that are implemented or can potentially be implemented in the enterprise in production, forecast parameters of future performance.

To justify the best expected result from the implementation of measures to increase the level of innovation activity of enterprises develop alternative solutions to problems, the tools of which include:

– modernisation of enterprises to increase their competitiveness;

– updating the traditional range of products;

– production of innovative products;

– introduction of innovative methods in operational activities, personnel development, marketing and logistics, aimed at maximizing customer satisfaction and profit (Fig. 7).

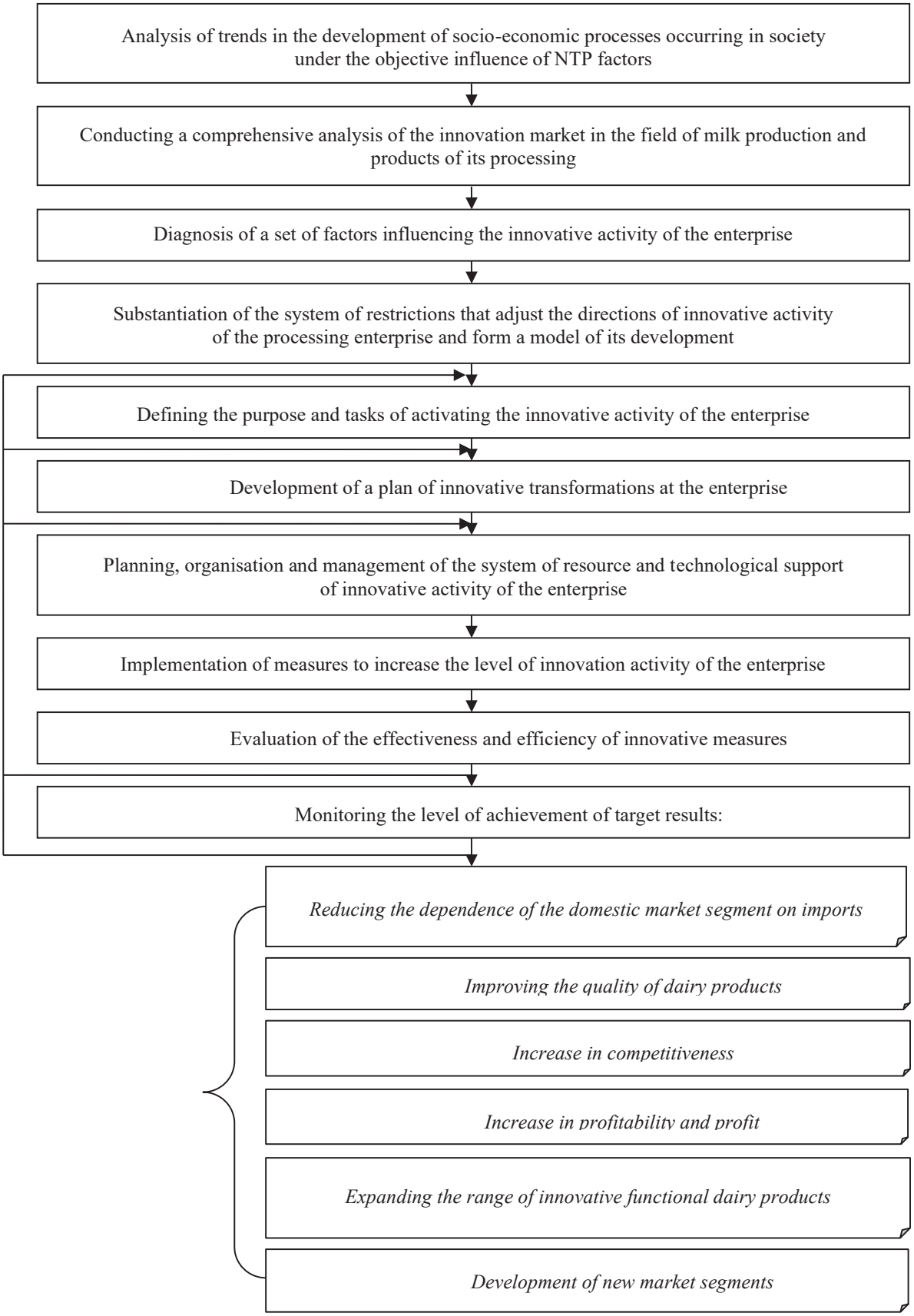

Figure 7. Algorithm for increasing the innovative activity of the processing plant
Source: compiled by the author

Conclusions

The vector of progressive development of the dairy industry focuses on the sequence of organisational and technological chain and adaptive system of innovative support for dairy production, based on the results of research teams in the raw materials and processing industries.

Innovative tools for the development of dairy enterprises include priority areas for improving the selection of raw materials for in-depth processing, production of special types of dairy products with high biological and nutritional value and guaranteed quality and safety of energy-saving equipment of reduced metal content, higher productivity and production efficiency.

Systematic formation and strategic purposefulness of interrelated scientific developments and practical achievements provide innovative development of raw materials and milk processing and have a comprehensive impact on the press to stabilize and further develop the dairy industry and can create a positive synergistic effect.

Prospects for the development of the raw material base of the dairy industry on the basis of time series and a forecast built by 2025 on mathematically established patterns of its operation for the period 2016-2021 indicate a reduction in livestock and productivity of cows and milk production in 2025 at 2020 9287 thousand tons. The supply of milk to milk processing enterprises will amount to 3314 thousand tons, or 37.5% of agricultural production.

The level of consumption of milk and milk products in terms of milk per capita in 2025 will be 200 kg, or 51.2% of the rational norm of 390 kg, to achieve which milk production should increase to 18,124 thousand tons. According to the perspective trends of volumes and assortment structure of dairy products of processing enterprises, the production of butter in 2025 will remain at the level of 2020 with the increase of some of its sour milk types for baby food, milk and condensed cream.

Increasing the level of innovation activity of dairy enterprises is based on the relationship between participants in the marketing chain of production and processing of milk and dairy products, their infrastructure links and resource capabilities, organisational and managerial measures for technical, technological and product innovations and alternative solutions to problems.

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Перспективи підвищення рівня інноваційної активності молокопереробних підприємств

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► **Анотація.** Прогресивний розвиток молочної галузі потребує удосконалення технологій кормовиробництва, утримання, годівлі, нарощення поголів'я тварин, ведення селекційно-племінної роботи в господарствах, підвищення генетичного потенціалу порід, доїння корів, зберігання й переробки молока та виробництва необхідного для населення асортименту молокопродукції. Успішна реалізація цих технологічних процесів потребує дієвої системи інноваційного забезпечення молочного виробництва, важливе значення для якого мають наукові розробки установ Національної академії аграрних наук України. Водночас здатність молокопереробних підприємств до інноваційного розвитку визначається трансформаціями їх господарського механізму шляхом впровадження технічних, організаційних та управлінських досягнень у сфері технологій. Мета статті – дослідження сучасних реалій, можливостей та прогнозування основних вимірів щодо активізації інноваційної діяльності молокопереробних підприємств України. У процесі дослідження використано низку методів: монографічний; порівняльний аналіз; прогнозування; табличний; розрахунково-конструктивний; графічний, абстрактно-логічний. Встановлено наявність адаптованої системи інноваційного забезпечення та систематизовано наукові розробки контролю при відборі молочної сировини, вітамінної натуралізації молока, технологій виробництва дієтичних молочних продуктів, автоматизації виробничих процесів, теплової обробки молока з використанням сучасних матеріалів упаковки для продовження терміну його зберігання, впровадження інноваційних методів в операційну діяльність, розвиток персоналу, маркетинг і логістику, використання яких доцільно поширювати у системі господарського механізму функціонування і розвитку молочної галузі. Визначено прогнозні показники сировинної бази молочної галузі України, яка у 2025 році залишиться на рівні 2020 року і становитиме 9287 тис. тонн, при зростанні обсягів виробництва молока у сільськогосподарських підприємствах на 13,0 % і зниженні і в господарствах населення на 5,0 %. Встановлено необхідні обсяги виробництва сировини для забезпечення виробничих потужностей молокопереробних підприємств і раціональної норми споживання молока та молокопродуктів. Побудовано динаміку прогнозних показників виробництва молочної продукції в Україні. Обґрунтовано пріоритетні цільові настанови стратегії активізації інноваційної активності молокопереробних підприємств. Запропоновано алгоритм підвищення інноваційної активності переробного підприємства. Вказані підходи та результати дослідження можуть бути використані органами державного і галузевого управління під час організації моніторингу та розробки пріоритетних заходів щодо активізації інноваційної діяльності підприємств української молочної галузі

► **Ключові слова:** молоко, молочна продукція, інновації, виробництво, переробка

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Trends in the Development of Ukrainian Grain Exports in the Context of Observance of State Food Security

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► **Abstract.** Progressive increase in exports of Ukrainian agricultural and food position, maintaining the leading position of the state in world commodity markets in the agri-food segment, especially in the grain market should not pose a threat to food security and the emergence of shortages in the domestic market. The article is devoted to the identification of features and indicators of effective realisation of the export potential of the Ukrainian grain market in view of the food security of the state. The methodological basis of the study was a number of general and special research methods, in particular, the dialectical method of cognition, the method of comparisons, empirical, graphical and abstract-logical methods. The result of the study is the identification of trends in foreign economic relations in the field of grain trade. Potential threats to Ukraine's food security from the increase in the volume of export-import operations in the grain market have been identified. The need for state coordination of processes to eliminate potential threats to the internal market has been highlighted. Theoretical and methodological approaches to the regulation of foreign economic transactions in the grain market based on the definition of tools to correct existing disparities in the realisation of economic interests of producers and traders in the context of food security gained further development. Along with the positive changes in the development of international grain trade, potential threats to the country's food security and to domestic market operators were identified. Proposals for their elimination by active methods of state regulation were substantiated

► **Keywords:** export structure, grain market, export potential, provision of demand in the domestic market

► Introduction

Development of foreign trade in agricultural products has been in the center of attention of researchers for decades in view of the effective solution of problematic issues of stable increase of economic efficiency of Ukrainian agro-industrial production. At the same time, Ukraine was and remains one of the world leaders in grain exports, however, the growth of revenues from foreign economic activity does not affect the economic efficiency of producers, and, for the most part, increases the efficiency of intermediaries [1]. In particular, according to the UN FAO, Ukraine is one of the ten largest grain exporters and ranked seventh in the world in the 2020-2021 and 2021-2022 marketing years (in the grain market from July to June) [2]. In addition, the lack of effective export control tools, especially non-tariff, leads to threats to food security, as the choice between selling products on the domestic market to processors and exports is mainly decided in favour of exports conditioned upon higher economic efficiency of such operations for the enterprise-transmitter [3]. This can lead and from time to time leads to a decrease in inventories of domestic market operators to critically low levels, which do not provide the minimum biologically justified amounts of food consumption [4]. Such a situation is a consequence of unsystematic realisation of the export potential of the agar sector of the Ukrainian economy, requires a comprehensive scientific study and organisational, managerial and regulatory correction.

Problematic issues of foreign economic activity with agricultural products, involvement of agricultural enterprises in export operations [5-7], promotion of products of Ukrainian agricultural producers in foreign markets [8-10], ensuring its competitiveness in these markets, development and realisation of export potential of Ukrainian agricultural production leading Ukrainian agrarian economists was considered in detail by leading Ukrainian agrarian economists in their scientific works [11-13]. The study [7] analysed in detail the role and place of marketing mechanisms for the management of sales of agri-food raw materials, including grain products, in domestic and international markets, considering seasonal price fluctuations and other specific factors.

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According to [8], the leading players in international trade today are not so much those countries that are provided with natural and climatic, soil, human resources, as those that actively develop and implement innovative technologies of cultivation, primary and secondary processing, storage and transportation of products, means of protection, fertilizers, advanced technical means, etc. According to foreign scientists [14], Ukraine is objectively included in the list of world leaders in grain exports and will maintain these positions for a long time.

According to some researchers [11] "Despite the significant potential, wheat production and grain quality in Ukraine is very unstable, conditioned upon the annual change in areas allocated for crops depending on demand for the crop, availability and quality of seed, a high dependence degree of crops on climatic conditions, methods and means of tillage, opportunities for the application of modern agricultural cultivation technologies, provision of labour resources, means of production and many other factors."

Thus, despite the rather wide range of issues considered in the studies of these scientists, which is related to the development of export potential of Ukrainian agricultural production, the issues of rationalisation of export regulation, combination of tariff and non-tariff regulation remain insufficiently studied. This necessitates the definition of tools to correct existing disparities in the realisation of economic interests of producers and subjects of the circulation of products in the context of food security.

The purpose of the article is to identify the parameters of successful realisation of the export potential of the Ukrainian grain market in view of the food security of the state.

▸ Materials and Methods

At the first stage of the study, a key hypothesis was formulated about the decisive role of the grain industry in the development of Ukraine's economy and the development of food security. In the structure of this hypothesis, structural elements were singled out — questions, the answer to which could refute or confirm it.

– How does the grain industry affect the state's economy and food problem?

– Is the distribution fair to all participants in the process?

– Is it possible to improve the current state of affairs?

Analytical reports of the State Statistics Service of Ukraine, including generalised data of the Ministry of Economy of Ukraine and the Ministry of Agrarian Policy and Food of Ukraine served as an information base to confirm this hypothesis. Also, some of the information was obtained through personal interviews with agri-food producers, agricultural market operators, and in scientific discussions with fellow scientists during seminars and conferences.

By using the dialectical method of cognition of processes and phenomena, researchers were able to explore and generalise the basic principles of development of both the structure and dynamics of the object of study.

The next stage was the analysis of existing scientific developments and achievements of Ukrainian and leading foreign scientists on the regulation of foreign economic activity in the grain market, the development of export potential of the industry, which was carried out using the traditional monographic method. In this context, it was important to conduct a differentiated analysis of Ukrainian and foreign literature, from the standpoint of comparing methodological approaches.

To determine the impact of the growth of Ukrainian grain exports on food security in the country, a number of general and special research methods were used. In particular, by using the method of comparisons, the dynamic changes in economic indicators of exports were analysed, in particular by marketing years. The application of the empirical method allowed comprehensively assessing the current state of international grain trade by agricultural market operators and establishing the proportions of participation of agro-traders and direct producers. Some at this stage the method of observing the behaviour of market participants was applied.

To visualise the dynamics and structure of grain trade, we used a graphical method of presenting information. At the final stage, the authors made theoretical generalisations with subsequent formulation of conclusions based on the use of abstract-logical method.

▸ Results and Discussion

One of the key guidelines for the development of the agricultural sector of the Ukrainian economy and an essential component of the system of agricultural policy of the state is to increase exports of Ukrainian agri-food products in order to multiply revenues from external sources.

The study of Chinese researchers [15] shows that foreign trade in grain significantly affects the parameters of safe functioning of national economic systems in the medium and long term, and has a significant impact on certain political relations and, consequently, political security. In addition, the paramount importance of effective intersectoral cooperation is determined by the leading role of grain in the agro-industrial economy, food security, the deveelopment of state, interstate and interregional economic ties of the country [16]. In turn, measures aimed at liberalising the regulation of grain exports in the tariff and non-tariff areas, which have been carried out in recent years, have strengthened the role of Ukrainian grain traders in foreign and domestic markets, because along with the real increase there are opportunities for a significant increase in the level of market power of the subjects of the circulation of agricultural products within the country, regardless of improving the efficiency of producers. At the same time, regulatory influence focused on the priority of exchange transactions with commodity consignments of grain in the domestic market has led to the acquisition of Ukrainian grain traders, conditioned upon the extremely high concentration of their capital, actual control over this area of trade in agricultural goods for further export.

The waiver of grain export quotas, finally implemented in 2019 [17], the only regulatory practice of the state made the conclusion of memoranda of understanding between the relevant ministry and grain market operators and led to significant threats to food security through deregulation of the market and uncontrolled leaks of significant production volumes abroad in the interests of a limited number of grain traders. In particular, in 2021 Ukraine exported 72% of grain produced [4]. This practice has been used in Ukraine for 11 years, however, when such documents were supplemented by means of quotas and export licensing, the state better regulated the proportions of exports, and the liberalisation of public-private relations in this area created a number of threats to related industries of agro-industrial production and food industry in terms of providing them with raw materials for processing and production of goods with a larger share of value added. At the same time, this situation poses the greatest threat to the food security of the state, as the largest incomes of exporters are generated by operations with grain food conditions, and the lack of effective control over the volume leads to a decrease in stocks in the domestic market.

It should be noted that revenues from grain exports in Ukraine in recent years are quite stable (Fig. 1) despite fluctuations in the volume of exported products in kind. During 2018-2021, the state's economy steadily received more than 9 billion dollars of grain export earnings. However, in this context, the problematic issue is the distribution of export earnings, primarily in terms of the participation of producers in the use of export earnings. Unfortunately, currently the marketing infrastructure of the domestic grain market is built so that producers, with the exception of a few vertically integrated structures, mostly holding type, which, along with foreign trade, are engaged in the production, storage and transportation of grain. At the same time, the largest share of producers, which are agricultural enterprises, are not able to participate in exports conditioned upon the inability to accumulate commercially significant batches of products of uniform quality, and therefore forced to cooperate with trade entities and vertically integrated structures that already export products receiving appropriate financial results. This does not contribute to the development, efficiency and financial and economic stability of most producers.

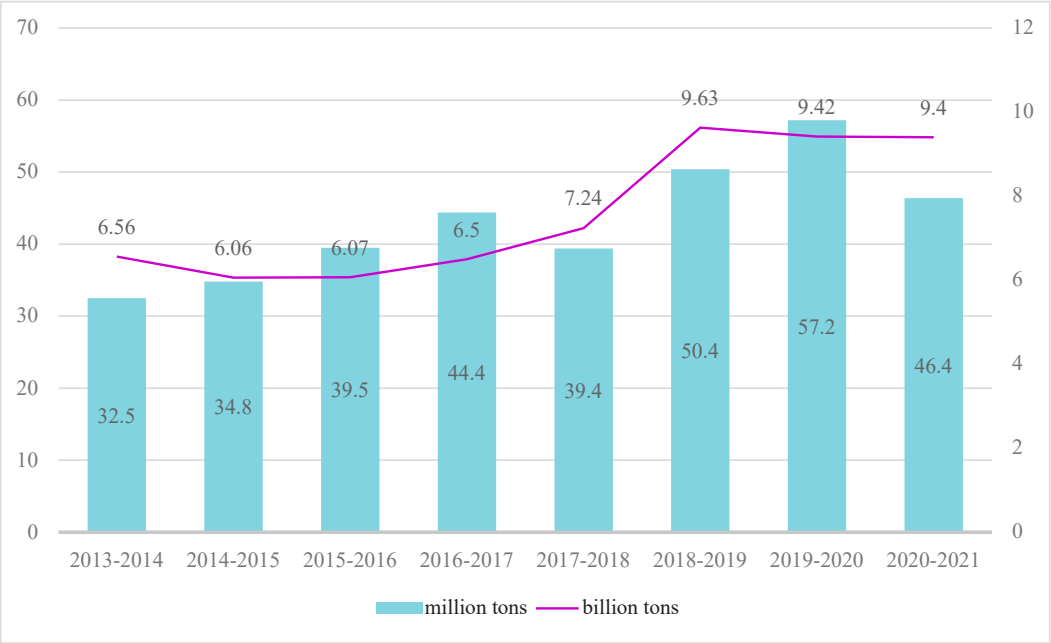

Figure 1. Grain exports in Ukraine in the 2013-2021 marketing years
Source: According to the State Statistics Service of Ukraine, the Ministry of Economy of Ukraine and the Ministry of Agrarian Policy and Food of Ukraine [18; 19]

Export orientation leads to distortions in the commodity nomenclature of grain production in the country, which consist in the reduction of types of crops grown by commodity producers, the corresponding changes in the structure of crop rotations, etc. The key reason for such shifts is the relative guarantee of sales of manufactured products. However, conditioned upon incomplete solution of the problem of storage and insufficient prevalence of futures and forward instruments in the domestic grain market, inadequate functioning of the exchange trading system, price pressure from the subjects of circulation on the producer does not allow to fully realise the production and commercial potential of enterprises-producers. This is indirectly evidenced by the commodity structure of Ukrainian grain exports (Fig. 2).

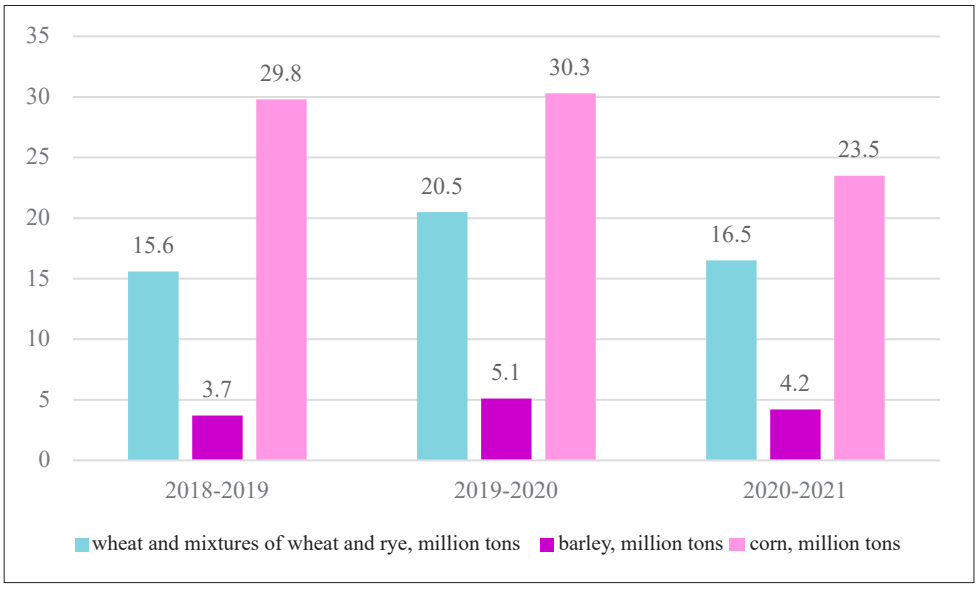

Figure 2. Commodity structure of grain exports in Ukraine in the 2018-2021 marketing years
Source: According to the State Statistics Service of Ukraine, the Ministry of Economy of Ukraine and the Ministry of Agrarian Policy and Food of Ukraine [18; 19]

Despite the significant successes of Ukrainian grain exporters in foreign markets, skillful finding of target foreign markets, successful positioning of batches of products on world commodity exchanges, well-established processes of transport logistics, export revenues are unproductive from the standpoint of the producer are distributed within the economic chain "production-storage-transportation-transshipment-export". In addition, the non-systemic nature of non-tariff regulation of exports leads to threats to the food security of the state. Thus, the situation in the first half of the 2021-2022 marketing year led to a critical decline in food grain stocks of wheat and its deficit in the domestic market for the needs of its own flour and cereals industry. As of the end of December 2021, according to the Ministry of Agrarian Policy and Food, "15.6 million tons of wheat grain were exported out of 25.3 million tons specified in the memorandum between the central executive body and grain market operators" [20]. It should be noted that the memorandum [21] does not contain information on the proportions of exports of feed and food grain of wheat. Accordingly, during the implementation of export operations, in particular, in the current 2021-2022 marketing year, wheat grain was mostly exported for food grain. As a result, the Ministry of Agrarian Policy and Food of Ukraine was forced to sign an annex to the memorandum in October 2021, which limited the export of wheat grain. However, its residues are no longer enough for domestic processing. As a result, Ukrainian companies began to increase exports of wheat flour from Turkey, produced, by the way, from previously exported wheat grain of Ukrainian production [20].

In this context, it is advisable to pay attention to the dynamics of food grain consumption in Ukraine (Fig. 3).

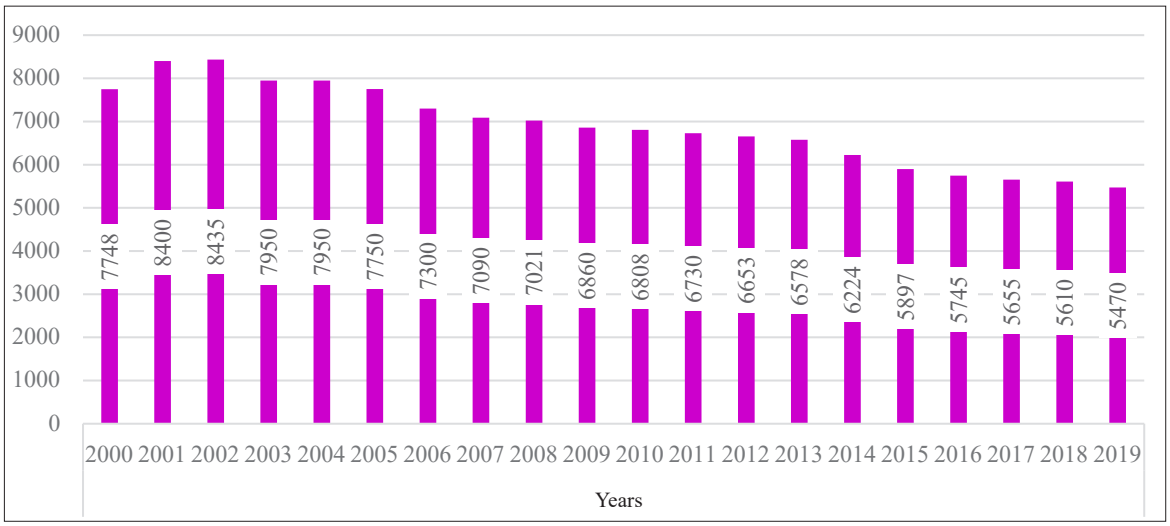

Figure 3. Consumption of food grain in Ukraine in 2000-2019
Source: data from the State Statistics Service of Ukraine [21]

The current system of regulation of foreign trade operations with grain, especially food, needs a significant transformation. It is also worth noting that grain is a low value-added product. However, despite the difficulties with the logistics of flour, cereals and pasta, it is the deepening of grain processing within the country and the export of high value-added products should become the main vector of development of Ukrainian production and exports.

▸ Conclusions

The study provides grounds to assert that the effectiveness and efficiency of Ukrainian grain exports are undeniable and have a significant impact on the state's economy in terms of foreign exchange earnings. However, the liberalisation of the system of tariff and non-tariff regulation, primarily through the refusal of quotas and licensing of exports critical to compliance, has led to disparities in supply in the domestic market. In addition, the results of the analysis allow speaking about the need to comply with the food security of the state in terms of providing wheat grain food conditions.

The use of such instruments as the signing of memoranda of understanding for each marketing year between the central executive body implementing agricultural policy and grain market operators without the use of effective export control tools, the use of other instruments does not provide full guarantees of the absence of disparities in the domestic market and, consequently, domestic consumption.

Thus, in the current situation, the decisive role of the state as a full participant in the processes on the international market is actualised. In particular, the interests of the state in terms of economic and food security must be coordinated. The study considers the urgent need to reorient the structure of exports of raw materials at least for primary processing, which will allow obtaining added value. In addition, it is necessary to understand the risks associated with the use of seaports in the context of the existing military conflict with the Russian Federation in eastern Ukraine. Will the state be able to use their capacity to its full potential in the event of an escalation of the conflict, and what kind of transport can be an alternative in this case.

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Тенденції розвитку українського експорту зерна в контексті дотримання продовольчої безпеки держави

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▸ **Анотація.** Поступальне нарощування експорту української сільськогосподарської та продовольчої позиції, підтримання лідируючих позицій держави на світових сировинних ринках в агропродовольчому сегменті, передусім, на ринку зерна не повинно створювати загрози для дотримання продовольчої безпеки та виникнення дефіцитних явищ на внутрішньому ринку. Стаття присвячена ідентифікації особливостей та показників ефективної реалізації експортного потенціалу суб'єктів українського ринку зерна з огляду на дотримання продовольчої безпеки держави. Методичну основу дослідження склала низка загальних та спеціальних методів дослідження, зокрема, діалектичний метод пізнання, метод порівнянь і співставлень, емпіричний, графічний та абстрактно-логічний методи. Результатом дослідження є ідентифікація тенденцій розвитку зовнішньоекономічних відносин у сфері торгівлі зерном. Визначено потенційні загрози для продовольчої безпеки України від збільшення обсягу експортно-імпортних операцій на ринку зерна. Актуалізовано необхідність державної координації процесів з метою усунення потенційних загроз для внутрішнього ринку. Набули подальшого розвитку теоретико-методичні підходи щодо регулювання зовнішньоекономічних операцій на ринку зерна на основі визначення інструментарію виправлення існуючих диспропорцій в реалізації економічних інтересів товаровиробників та суб'єктів сфери обігу продукції в контексті дотримання продовольчої безпеки. Поряд з позитивними змінами у розвитку міжнародної торгівлі зерном визначено потенційні загрози для продовольчої безпеки країни та для внутрішніх операторів ринку. Обґрунтовано пропозиції щодо їх усунення активними методами державного регулювання

▸ **Ключові слова:** структура експорту, ринок зерна, експортний потенціал, забезпеченість попиту на внутрішньому ринку

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Directions of Reforming the Ecological Taxation System of Ukraine in the Conditions of Development of European Integration Processes

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► **Abstract.** One of the main tasks of humanity on the agenda is the preservation of this planet as a prerequisite for the functioning of everything we interact with, where we live and what we stand for. Every day, 9 out of 10 inhabitants of the Earth are forced to breathe polluted air, which affects their health, penetrating the respiratory and circulatory systems and disrupting the brain, lungs and heart. Therefore, there is a need to find new and improve existing levers of impact on pollutants in the world as a whole and in Ukraine in particular, given the successful foreign experience of European countries. One of these levers is environmental taxation, as part of the financial policy of the state. The purpose of the article is to substantiate and highlight the main ways to reform the environmental taxation system of Ukraine in the context of the development of European integration processes. The basis of research methodology are abstract-logical method, dialectical method of scientific knowledge, analysis, deduction, synthesis, statistical, graphical and tabular. The main ways of reforming the system of ecological taxation of Ukraine in the conditions of development of European integration processes and experience of the EU countries are generalised. The classification of environmental tax bases according to Eurostat (Eurostat) and the Directorate General of the European Commission for the Environment (The European Commission's Directorate General Environment) is substantiated. Scientific and methodological approaches to the definition, identification and improvement of elements of the mechanism of environmental taxation and the structure of distribution of revenues to the relevant levels of the budget system of Ukraine have been further developed. The system distribution and assignment of the relevant components of compensation and regulatory payments to the environmental taxation of Ukraine according to the budget classification codes was improved. The main levers of tax policy to achieve environmental goals and encourage polluters to reduce the burden on the environment are substantiated. The results of the study can be used at the local and state levels to make decisions on reforming the environmental tax system in Ukraine

► **Keywords:** tax system, state budget, tax policy, tax mechanism, levers of tax regulation, CO_2 emission, financial mechanism

► Introduction

The World Economic Forum, Business Insider and the World Health Organisation emphasise the issue of climate change as one of the main issues on the agenda. According to WHO estimates, diseases caused by air pollution kill about 7 million people each year. The main sources of this pollution are hydrocarbon combustion, high emissions from industry, transport and agriculture [1; 2]. Mankind is on the brink of ecological catastrophe, so it is necessary to combine the efforts of governments of environmentally oriented countries such as Denmark, Sweden and Germany with major polluters such as China and the United States to best address the state of the environment [3].

From the standpoint of this issue, the authors analysed the functioning of environmental tax systems in the EU to adapt and implement best practices (Environmental tax reform, hyperemortisation of energy saving assets, shifting part of the burden on labor tax, capital, energy taxation, etc.) in Ukrainian realities. Environmental taxes as an instrument of environmental policy should not just fill the state budget, but encourage the payer to a conscious and responsible attitude to the environment. The accumulated resources can be used to stimulate environmental protection, government programmes for the development and import of energy-saving technologies, waste disposal and more.

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The problem of environmental taxation is the subject of research by many Ukrainian and foreign scientists. In particular, the theoretical principles of environmental taxation are devoted to the works of: W. Baumol [4], who conducted a thorough and comprehensive analysis of economic theory of environmental policy; E. Smeets and R. Weterings [5], who classified ecological indicators by types; H. Vollebergh [6], who raised the issues of assessing nature and the environment, sustainable national income and economic growth; F. Biermann, [7] in terms of using taxes and subsidies to internalise externalities; A. Sandmo [8], who analysed the optimal rates of environmental tax, proposed to set a rate for goods that create an excessive burden on the environment not only based on public costs of pollution, but also considering the elasticity of demand. Issues of practical and effective functioning of environmental taxes were dealt with by: T.P. Halushkina [9], who outlined the existing trends in the field of nature management; M.I. Sovyk [10], which highlights the concept of the functioning of environmental taxation as a mechanism to increase the competitiveness of the economy; Yu.P. Synytsina [11], which describes the signs of ecological and economic transformation that determine the dominant evolution of society; L.S. Hryniv [12], who highlighted the theoretical and methodological principles and latest concepts of environmental economics; A.L. Bobrovskyi [13], who described the principles and foundations of the state system of environmental management and others.

However, despite the significant contribution to the study of this issue, it is necessary to further develop and study the issue of effective functioning of tax instruments of financial policy to regulate activities related to the environment and increase the efficiency of regulatory and fiscal capacity of environmental taxation. *The purpose of the article is* to explain and highlight the priority areas of reforming the environmental taxation system of Ukraine in the context of accelerated European integration processes.

▸ Materials and Methods

In the course of the research, the authors first studied the trends in the interaction between regulatory authorities and polluters in Ukraine and the EU, along with the dynamics of tax revenues using the method of analysis; the following were used abstract-logical and dialectical methods to substantiate the theoretical principles of the environmental taxation system and the understanding of European integration processes with the policy of "The EU Green Deal"; statistical, graphical and tabular methods were used to collect, compare, process and analyse statistical data, highlight patterns and describe the results of the study; methods of synthesis and deduction allowed carrying out structural construction of work, studying systems of ecological taxation of the EU countries and forming specification of values of categorical tools of a research subject.

The information base of this material is the legislative and regulatory acts of Ukraine [14; 15], materials of the State Statistics Service of Ukraine [16], the Ministry of Finance of Ukraine [17], the Ministry of Economy of Ukraine [18], Eurostat [19], the United Nations [20], publications and materials of the Organisation for Economic Cooperation and Development (OECD) [21], IMF [22], scientific works of Ukrainian and foreign scientists.

▸ Results and Discussion

The study identified that one of the most ambitious and comprehensive environmental protection programmes is "The EU Green Deal", proposed by the EU on 12/11/2019 (Fig. 1). This strategy aims to achieve zero CO_2 emissions by 2050 and rethink the EU economy in terms of resource efficiency. While the process of economic growth will be separated from the progressive use of energy resources. The need for The EU Green Deal strategy arose conditioned upon the increasing pace of climate change and accelerated global warming because of human activity [23].

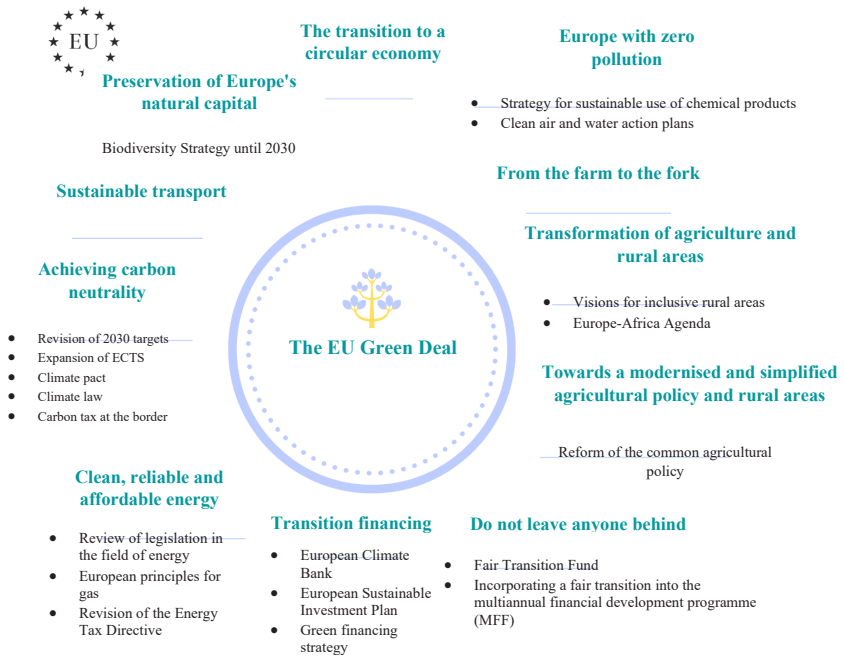

Figure 1. European Green Course Strategy

Source: compiled by the author based on data [23]

Given the EU's well-established comprehensive strategy for climate neutrality, Ukraine faces numerous challenges in the form of promoting environmental management, environmental protection, control and modernisation of the carbon dioxide taxation system, targeted use of accumulated funds from the environmental tax, but on the other hand, the corresponding opportunities for the creation of an ecological center of Europe, the development of organic production and modernisation of the existing system of environmental taxation (Fig. 2). Based on the main functions of taxation (fiscal and regulatory), environmental payments are usually divided into regulatory and compensatory. Payments made for any negative impact on the environment are called regulatory. Their main purpose is to stimulate the prevention of actions that harm the environment (for example, payments for environmental pollution, waste disposal, etc.). Another group is formed by compensatory payments, which are aimed at collecting money and accumulating them in special environmental funds (for example, fees for special use of natural resources). In contrast to the regulatory ones, these payments are aimed at financing environmental measures and are not directly related to the magnitude of the negative impact on the environment and resources [24].

Ukraine's environmental taxation system

Compensation payments

Rent for special use of water

Rent for special use of forest resources

Rent for subsoil use

Rent for the use of radio frequency resources of Ukraine

Fee for the use of other natural resources

Rent for transportation of oil and oil products by main oil pipelines

Regulatory payments

Environmental tax

- Emissions of pollutants into the atmosphere
- Discharges of pollutants directly into water bodies
- Disposal of waste (except for secondary raw materials) in specially designated places or facilities
- Generation of radioactive waste (including already accumulated)
- Temporary storage of radioactive waste by their producers beyond the license period established by special conditions
- Volumes and types of fuel, including those produced from toll raw materials, sold or imported into the customs territory of Ukraine by tax agents (excluded based on the Law No. 71-VIII of 12/28/2014)
- Fee for environmental pollution (expired on 02/11/2011)

Figure 2. Environmental taxation system of Ukraine
Source: compiled by the author based on data from [19]

According to EU Regulation No. 691/2011, the OECD and the International Energy Agency include environmental taxes, the tax base of which is a physical unit or its equivalent (conditional unit), which determines the proven burden on the environment and which is defined in the European System of Accounts (ESA 2010) as a tax [21]. The Directorate for Taxes and Customs Duties of the European Commission has divided environmental taxes into seven groups according to the areas of use: 1) energy taxes (for motor fuel, energy fuel, electricity); 2) transport taxes (kilometers traveled, annual tax from the owners, excise duties on the purchase of a car); 3) payment for pollution (emission of pollutants into the atmosphere and water bodies); 4) payment for waste disposal in landfills and their processing; 5) taxes on emissions of substances that lead to global change (ozone depletion); 6) tax on noise exposure; 7) payment for the use of natural resources [25; 19].

The general classification used in the EU, OECD and IEA is the distribution of environmental taxes by type of object of taxation is shown in Figure 3.

Environmental taxation system in the EU (generalised classification)

Energy Tax

- excise taxes on energy resources (gasoline, diesel, liquid fuels, natural gas, coal and electricity);
- taxes on CO_2 emissions, which in most countries are indirect and set as a supplement to energy taxes;
- taxes on potentially environmentally hazardous industries.

Transport Tax

- taxes related to the possession and use of motor vehicles and other vehicles;
- taxes on transport services that meet the general definition of environmental taxes;
- one-time taxes related to the import or sale of vehicles;
- periodic taxes.

Pollution Tax

- taxes on emissions of pollutants into the air;
- discharges of pollutants into water bodies;
- noise exposure;
- payments for activities related to solid waste management.

Resource Tax

- payments related to the extraction or use of natural resources
- payment for licenses for hunting, fishing, etc.

Figure 3. Generalised classification of the EU environmental taxation system
Source: compiled by the author based on data from [19]

To compare the tax burden of activities that harm the environment, the authors considered the value of tax revenues from environmental tax in % of GDP in Ukraine and EU countries (Fig. 4). Among the analysed countries we can single out Denmark, which fills its budget conditioned upon environmental taxation by 3.17% of GDP in 2020 with weakening dynamics compared to 2007 and Estonia (2.45% of GDP with strengthening dynamics until 2020). The group of countries, namely Poland, Slovakia and Sweden, keep the tax burden at around 2.02-2.55%, which is approximately equal to the average income of the 27 EU member states (2.24% of GDP). Germany accumulates environmental taxes of about 1.71% of GDP with a decrease in revenues compared to 2007, which is due to real GDP growth.

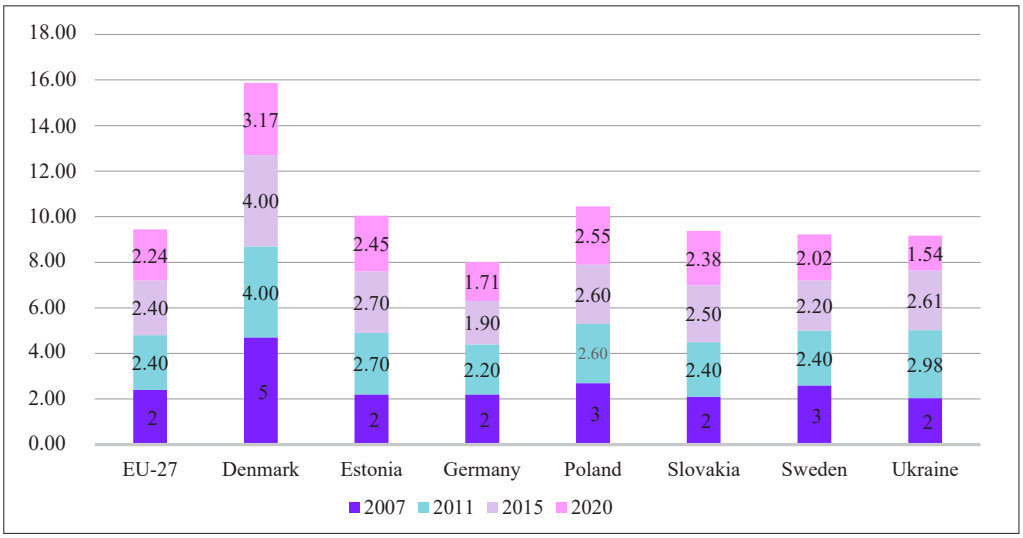

Figure 4. Dynamics of budget filling conditioned upon environmental taxation in Ukraine and EU countries, % of GDP
Source: compiled by the author based on materials [19; 26]

While in Ukraine there is an increase in environmental revenues from 2% of GDP in 2007 to 2.98% in 2011 and a decline to 1.54% of GDP in 2020. Such fluctuations may be conditioned upon a decrease in GDP of 6.7% in 2011 compared to 2007 and the inclusion in environmental taxation of fees and charges for special use of natural resources in addition to rent, environmental tax and pollution charges. To assess the adequacy of revenues in the development of "green" economy of Ukraine, the current composition of environmental taxation and identify potential ways of reform analyzed the structural distribution of environmental taxes and revenues to the Consolidated Budget of Ukraine in 2011-2019 (Fig. 5)

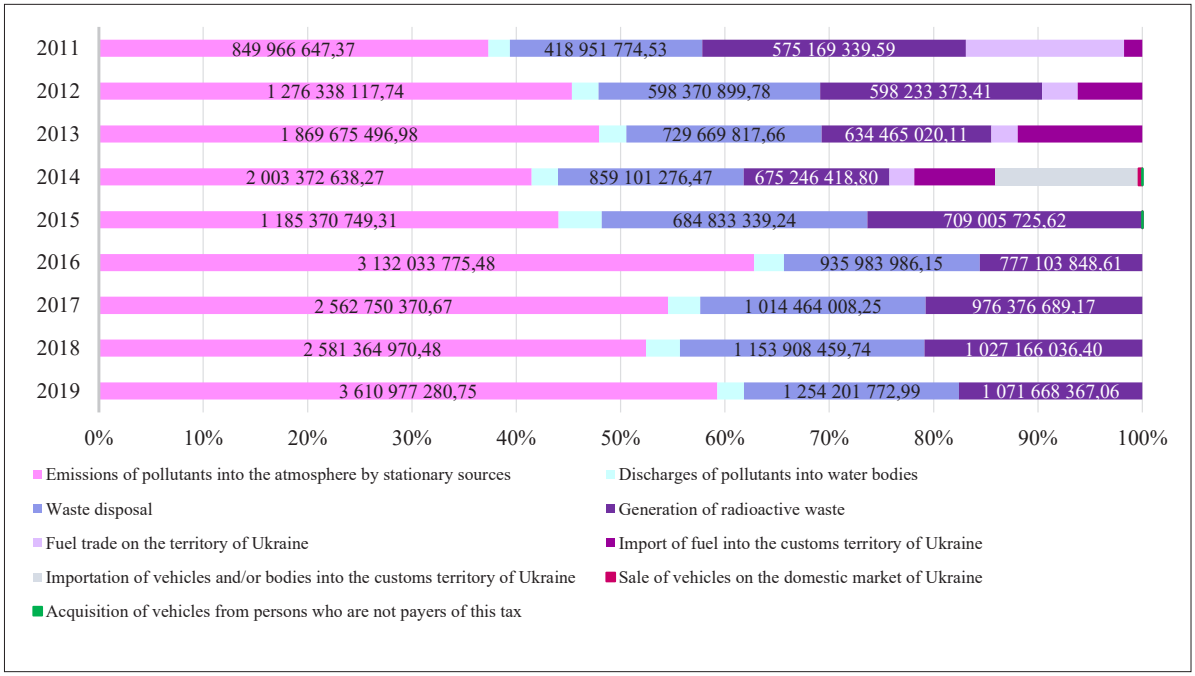

Figure 5. Dynamics of environmental tax revenues to the Consolidated Budget of Ukraine in 2011-2019, UAH
Source: compiled by the author based on data from [26]

These data indicate the predominance of revenues from the emission of pollutants into the atmosphere by stationary sources, about 59% in 2019. This is followed by revenues from waste disposal (20.6% in 2019) and environmental tax levied on the generation of radioactive waste (17.6% in 2019). The authors of the study also observed a sharp decline in revenues in 2015 against the background of hostilities and the exclusion from the revenue side of taxation of revenues from fuel imports into Ukraine and revenues from trade in own fuel in Ukraine.

As Figure 6 illustrates, the highest share of environmental tax was in local budget revenues in 2016 – 2.29% and decreased to 0.83% in 2019, while in the state budget for 2019 there was an increase of 0.57% with a peak value in 2014 – 1.31%.

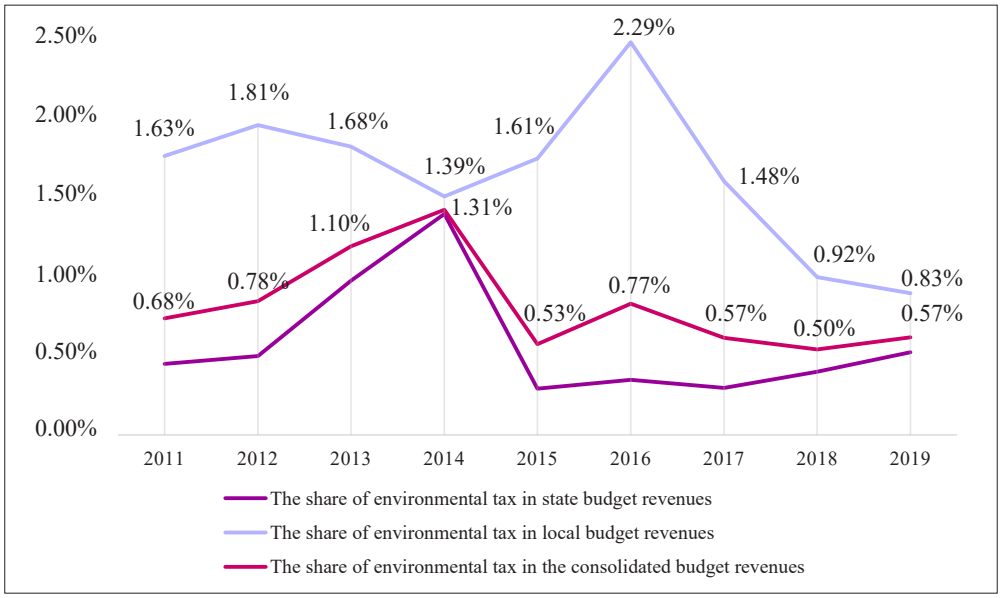

Figure 6. The share of environmental tax in budget revenues, % in 2011-2019
Source: compiled by the author based on data from [26; 27]

The next step is to analyse the structure of coverage of expenditures on environmental activities through environmental taxation (Fig. 7)

That is, there is a lack of funding for environmental measures through environmental taxation, which in turn necessitates an increase in the rate or expansion of the tax base. In combination with the given structural distribution of revenues from the payment of environmental tax by levels of the budget system in Figure 8, ambiguous conclusions were obtained.

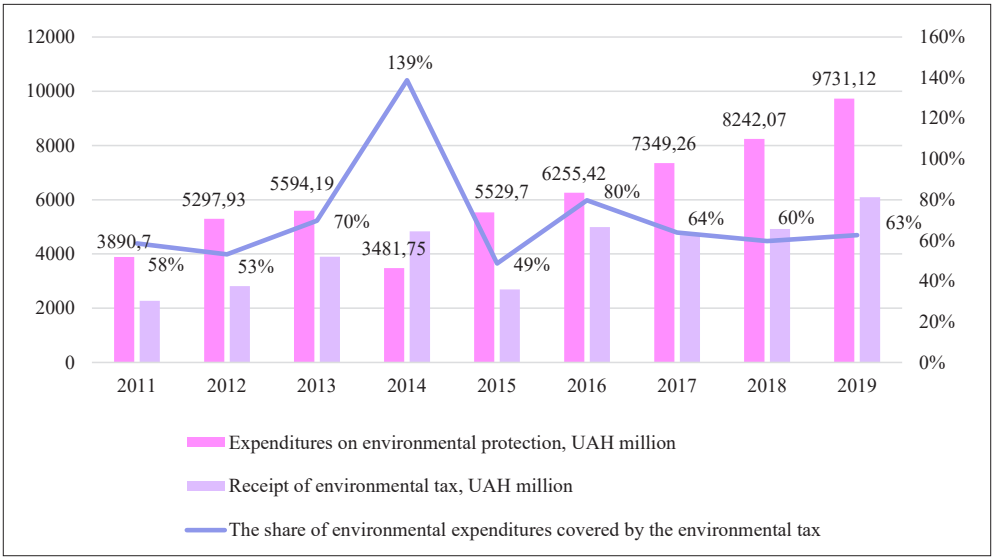

Figure 7. The ratio of environmental tax to expenditures on environmental measures, %
Source: developed by the author based on data from [26; 16]

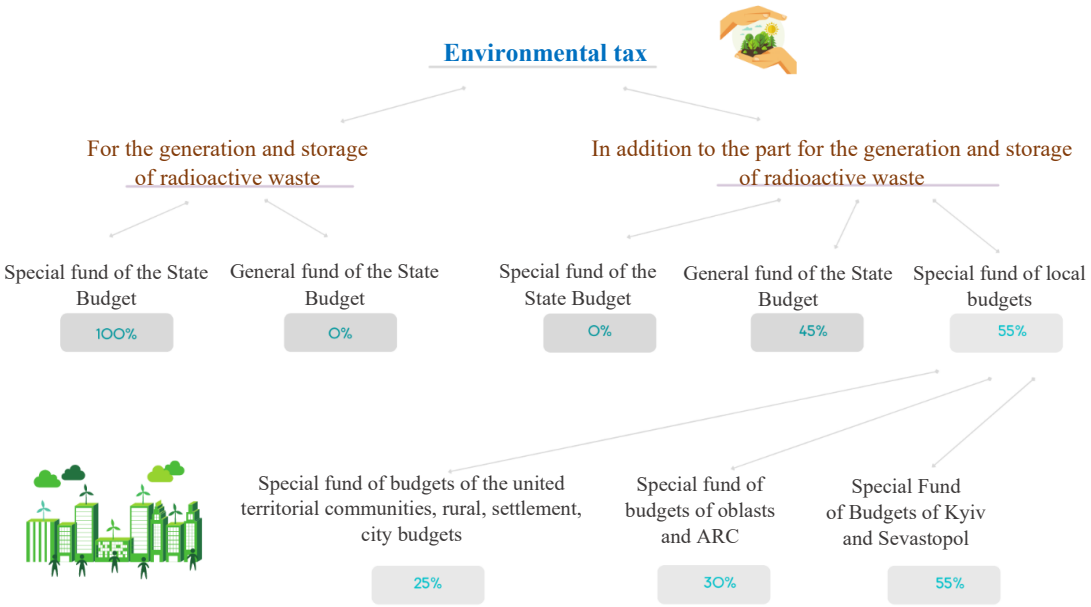

Figure 8. Distribution of revenues from the payment of environmental tax between the levels of the budget system in 2021, %
Source: compiled by the author based on data from [28]

On the one hand, the negative fact is that a significant part of the funds from environmental taxation is credited to the general fund of the state budget, where they are not earmarked, but environmental measures are funded more than taxes paid by pollutants. Funds for the generation and storage of radioactive waste are credited to the special fund of the state budget by 100%. The rest – to the special fund of local budgets and the general fund of the State budget in the proportion of 55/45 [28].

The CO_2 emission tax rate has only a Pig component (ie it must consider the public cost of pollution and the need to realise its fiscal potential). Among the main forms of taxes we can single out the tax on estimated or measured emission of greenhouse gas (emission base carbon tax), which is based on actual emissions and provides a complex procedure of control and consolidation and tax on energy consumption (fuel base carbon tax), the rates of which depend on carbon capacity in the fuel, which

allows for effective management and audit. The IMF recommends that the member states of the Paris Climate Agreement introduce a fee for a ton of CO_2 emissions at $ 75 by 2030. Denmark, Finland, Sweden and Norway were among the first countries to adapt their CO_2 emissions tax in addition to other energy taxes. Tax rates in some EU countries and Ukraine as of 2021 are shown in Fig. 9. The highest rates are set in Sweden – 116.33 euros per tonne of CO_2, Switzerland and Liechtenstein – 85.8 euros, Finland – 62.0 euros. And the smallest – in Poland: 0.07 euros, Ukraine – 0.25 euros, Estonia – 2.0 euros per ton of CO_2 [29].

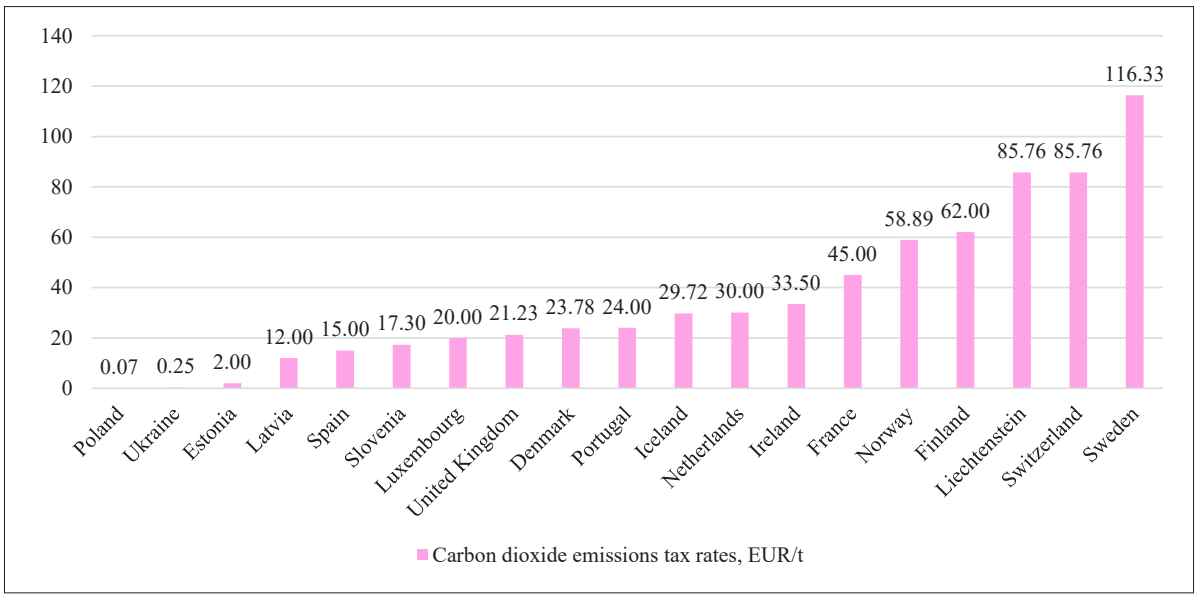

Figure 9. CO_2 tax rates in some European countries as of 2021
Source: compiled by the author based on data from [29]

Given the experience of the analysed EU countries, the practice of using CO_2 emissions taxes as an indirect tax on energy consumption remains relevant for Ukraine. This, in turn, will simplify administration, reduce the energy intensity of GDP and combat climate change.

International experience shows that to convert from an estimated emission tax to an energy consumption tax, the following coefficients should be used, which are the basis for compiling an inventory of greenhouse gas emissions from the Kyoto Protocol countries:

– the coefficient of carbon content in the fuel, which during combustion will be converted into CO_2;
– coefficient of calorific value;
– oxidation factor [29].

Thus, the main recommendations of the model of reforming the environmental tax system are (Fig. 10):

1. Balance of budget revenues due to efficient use of the country's resources and approximation of CO_2 emission tax rates to the European level. It is necessary to carry out taxation on a progressive scale and gradually increase the rate of environmental tax on carbon dioxide emissions by UAH 10 each year, to reach the level of UAH 50 per ton by 2024.

2. Increase the coefficient when charging for overlimit emissions and discharges of pollutants. Introduce a system of fines for environmental offenses.

3. Reorient environmental regulation from controlling the level of environmental pollution to energy taxation.

4. Ensure targeted use of revenues from the tax on CO_2 emissions from stationary sources to stimulate innovation, implement energy efficiency measures, adapt to climate change and reduce emissions.

5. Establishment of the State Fund for environmental protection as part of the special fund of the State Budget of Ukraine as a separate legal entity. Provide sources of 100% environmental tax for CO_2 emissions and 30% environmental tax in addition to the disposal of radioactive waste.

The results of the study were limited to 2019 conditioned upon the availability of data on tax revenues from the environmental tax of European countries, which have passed through the ESA-2010 system of accounts published by Eurostat [19] and data from the State Treasury Service of Ukraine [26].

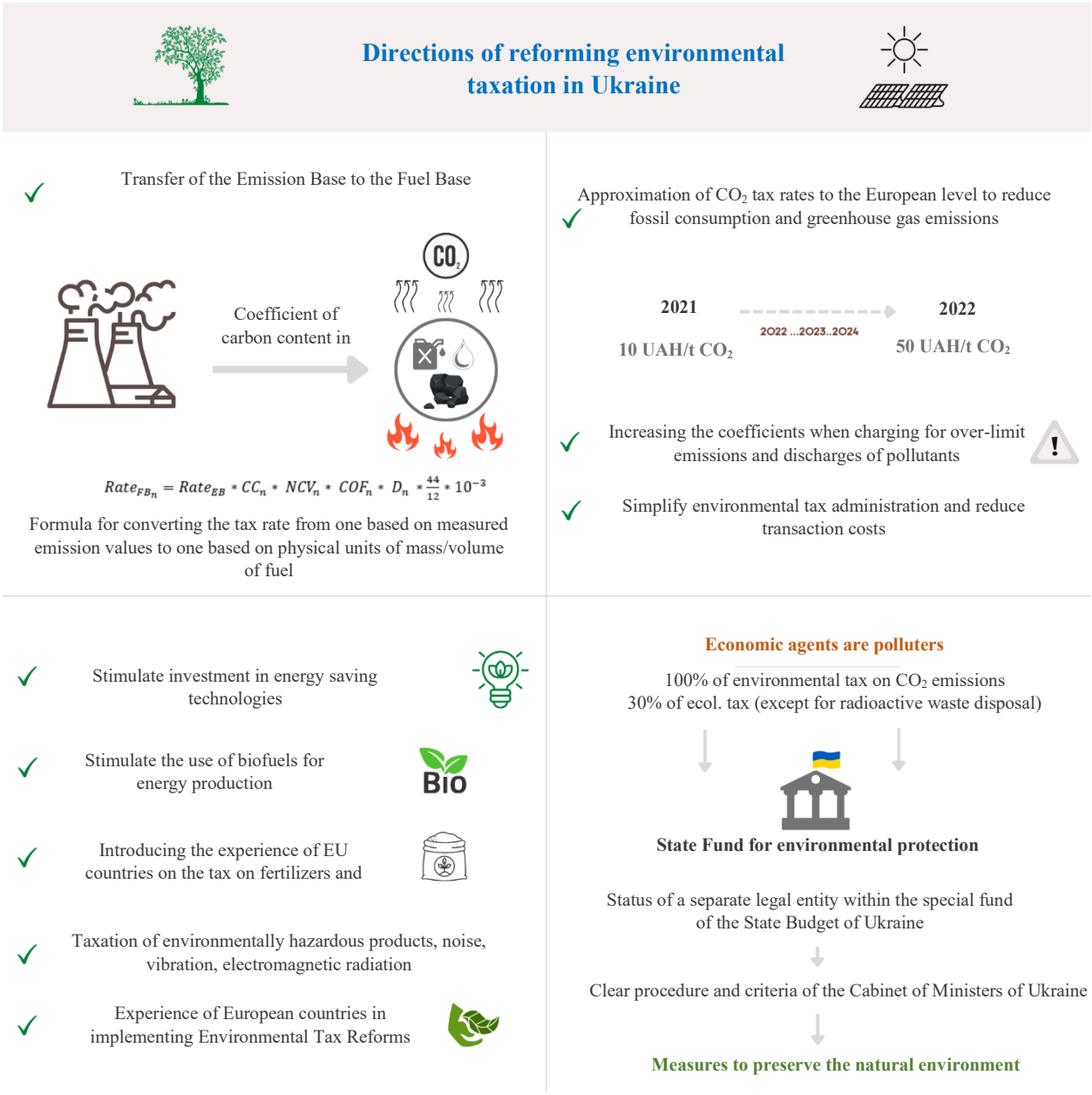

Figure 10. Directions of reforming the environmental taxation system of Ukraine
Source: developed by the author

▸ Conclusions

The study identified that taxes on carbon dioxide emissions, the rate of which consists only of the environmental component, and excise taxes on energy resources, in which the fiscal component is added to the environmental component, are effective tools to reduce CO_2 emissions. The experience of countries in stimulating the development and use of energy-saving technologies is interesting, including the provision of so-called R&D tax credits, which provide for compensation of part of the cost of technology by providing income tax rebates. Tax revenues from the environmental tax in Ukraine only partially cover the costs of environmental measures, which necessitates the mobilisation of most revenues and the creation of specialised trust funds. The reserves for reducing the burden on the environment can be quickly depleted, so it remains important to find options for giving economic growth new facets, so that the revival of the economy and industry is accompanied by the implementation of effective resource-saving technologies.

To achieve the goals of environmental policy, it is necessary to ensure targeted and effective use of funds accumulated from the environmental tax, stimulate modernisation and innovation of polluting entities in order to reduce the level of environmental pollution.

Therefore, it is necessary to further consider the issue of creating a separate fund as a legal entity for the effective accumulation and project targeted

use of mobilised funds under the control of the Ministry of Finance. It is also advisable to conduct in-depth research on the control of harmful emissions and the transition to energy taxation, together with the experience of countries in the taxation of environmentally hazardous products, vibration, noise, electromagnetic radiation.

Given the developed proposals, it is possible to increase the fiscal efficiency of the environmental tax on carbon dioxide emissions, create an opportunity to actually calculate and reflect the object of taxation in the reporting of economic agents, along with improving transparency and simplification of inspections. However, only raising the tax rate without innovative modernization of enterprises, support, development and import of innovative resource-saving projects, application of appropriate benefits for environmentally advanced tax agents will create an additional tax burden and will not reduce energy consumption and emissions.

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Напрями реформування системи екологічного оподаткування України в умовах розвитку євроінтеграційних процесів

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► **Анотація.** Одним із основних завдань людства на порядку денному постає питання збереження цієї планети як передумови для функціонування всього, з чим ми взаємодіємо, де живемо, та що відстоюємо. Кожного дня 9 із 10 мешканців Землі змушені вдихати забруднене повітря, яке впливає на стан їхнього здоров'я, проникаючи до дихальної і кровоносної системи та порушуючи роботу головного мозку, легень та серця. Тому виникає необхідність пошуку нових та удосконалення існуючих важелів впливу на забруднювачів як у світі в цілому так і в Україні зокрема, з огляду на успішний іноземний досвід європейських країн. Одним з таких важелів є екологічне оподаткування, як складова частина фінансової політики держави. Мета статті – обґрунтувати та висвітлити основні шляхи реформування системи екологічного оподаткування України в умовах розвитку євроінтеграційних процесів. Основу методології дослідження становлять абстрактно-логічний метод, діалектичний метод наукового пізнання, аналізу, дедукції, синтезу, статистичний, графічний і табличний. Узагальнено основні шляхи реформування системи екологічного оподаткування України в умовах розвитку євроінтеграційних процесів та досвіду країн ЄС. Обґрунтовано класифікацію баз оподаткування екологічних податків згідно з Євростатом (Eurostat) та Генерального директорату Європейської Комісії з питань довкілля (The European Commission's Directorate General Environment). Набули подальшого розвитку науково-методичні підходи до визначення, ідентифікації та удосконалення елементів механізму екологічного оподаткування і структури розподілу надходжень до відповідних рівнів бюджетної системи України. Удосконалено системний розподіл і віднесення відповідних компонентів компенсаційних та регулюючих платежів до екологічного оподаткування України згідно кодів бюджетної класифікації. Обґрунтовано основні важелі податкової політики задля досягнення екологічних цілей та стимулювання забруднювачів до зменшення навантаження на навколишнє природне середовище. Результати дослідження можуть бути використані на місцевому та державному рівнях з метою прийняття рішень стосовно реформування системи екологічного оподаткування в Україні

► **Ключові слова**: податкова система, державний бюджет, податкова політика, податковий механізм, важелі податкового регулювання, емісія CO_2, фінансовий механізм

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Implementation of Irrigation and Drainage Strategy: Political, Economic and Cultural Aspects

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▸ **Abstract.** The article is devoted to the current problems of institutional reform to attract investment in the modernisation and rehabilitation of irrigation infrastructure and cover the costs of its operation. To address these issues, in 2019 the Cabinet of Ministers of Ukraine approved the Irrigation and Drainage Strategy until 2030 and in 2020 a corresponding action plan for its implementation. However, the reform process is delayed conditioned upon systemic environmental, economic and cultural problems that create obstacles to change, primarily in the development and adoption of legislation regulating the formation and operation of new institutions (water user associations and management of state reclamation systems, etc.). The purpose of the article was to present the results of analytical studies examining Ukrainian and international experience in irrigation management reforms and assessing the likely risks that may arise in this way and forming a vision for managing the implementation of the Irrigation and Drainage Strategy until 2030. The study was performed using the following methods: systematic analysis of the functioning of the irrigation sector in Ukraine; comparison (determination of properties and characteristics based on collected information and statistical data on reform processes in the field of land reclamation in Ukraine and the world), abstract – logical (theoretical generalisations and formulations of categories and conclusions. The existing reform processes in the field of land reclamation in Ukraine are analysed, it is noted that in a market economy, effective maintenance and development of water reclamation complex can take place only in partnership with the state and the private sector. As a result of research of Ukrainian and international experience, the principles and mechanisms of effective implementation of transformations in irrigation management are proposed and consider socio-economic and cultural aspects of reform processes in Ukraine and possible risks arising from international experience. Specific recommendations for managing the reform process are provided. The application of the proposed methods of reform will ensure investment in the modernisation and rehabilitation of water infrastructure and further sustainable use of irrigated land

▸ **Keywords:** land reclamation, water management and reclamation complex, integrated management, institutional reform, transformation in irrigation management, water user associations, investments

▸ Introduction

According to the Food and Agriculture Organisation of the United Nations, today about 800 million people worldwide are chronically malnourished [1]. According to these international organisations, the world's population is expected to increase to at least 9.6 billion by 2050, so to ensure the food security of this growing population, agricultural production must grow rapidly and increase its volume by 60% (and almost 100% in developing countries) to the baseline indicators of 2005-2007 [2]. Thus, a new "green" revolution is needed [3], which this time, according to experts of the International Commission on Irrigation and Drainage (ICID), can be carried out only with the use of integrated water and land management [4]. At the same time, optimal resource management, considering the requirements of reducing the risks of increasing climate variability, can be ensured only by providing fair and reliable irrigation services that will increase agricultural productivity and preserve ecosystems.

Reclamation agricultural production in Ukraine is not realising its potential explained by the reduction of the area of actual irrigation and inefficient

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management of water resources in irrigation systems, which hinders the achievement of these complex requirements. According to the FAO, Ukraine is able to provide food to 450-500 million people annually, currently these opportunities are used by a third [5]. As of 1990, soil irrigation was 2.29 million hectares, but since independence this figure has almost quadrupled to about 500,000 hectares, while existing reclamation systems do not provide the projected productivity of water and energy resources [6; 7].

Thus, the low efficiency of irrigation systems, the rapid growth of water demand from entities in other sectors, such as housing, utilities, industry and energy, are just some of the main problems. Efforts to ensure sustainable water management will require improving the efficiency of irrigation systems by modernising and revitalising their management systems. At the same time, the recent introduction of market relations in the water management and reclamation complex of the state, agrarian reform and active development of agricultural entrepreneurship have significantly increased the requirements of producers to the quality and cost of irrigation water supply services. Ukraine, like most developing countries with irrigation systems, faces difficulties in furthering the ever-increasing irrigation costs and reimbursing producers for the opaque cost of water services, in addition to the urgent need to speed up the innovative revival of irrigated agriculture.

There is a need to address these issues, first of all, the successful implementation of new institutions and organisational development of irrigation management with the participation of water users with the adaptation of known models of their creation and operation to the conditions of Ukraine. At the same time, in the reform process, it will be important to avoid uncoordinated actions, misinterpretation of legal provisions and unreasonable political decisions.

An analysis of recent research suggests that the problems of effective water management in the agricultural sector are the focus of both international bodies, such as the Food and Agriculture Organisation (FAO), the Global Water Partnership, the United Nations, and public authorities. different levels and the world scientific community [8-10]. Foreign researchers have focused considerable attention on the prospects of transferring control of irrigation systems to associations of water users and the identified shortcomings in certain countries [11-13]. Developed recommendations and prepared final reports on the implementation of irrigation management programmes with an emphasis on the privatisation of reclamation systems [14-16]. At the same time, Ukrainian scientists developed the scientific basis for irrigation restoration and development [7], analysed the institutional support for efficient use of water resources in Ukraine under land reform [6; 17; 18] and explored innovative approaches to transforming management in irrigated agriculture [19; 20]. However, for all the previous time, the approbation of these studies did not provide a fully acceptable scientifically sound basis for a comprehensive systemic approach of the state and Ukrainian society to modern reform of land reclamation, especially given the exacerbation of socio-economic and climatic challenges undermining food security. Given this and the presence of possible risks in the implementation of the state strategy of irrigation and drainage, we have formed the basic principles and methods of its implementation. The implementation of the State Strategy for Irrigation and Drainage in Ukraine until 2030 [21], adopted by the government in 2019, requires a scientific basis for the success of new institutions, building the latest organizational structure of the industry and creating a favorable environment for their development. World irrigation experience shows that the transfer of irrigation system management (TISM) to new NGOs, in the absence of strong support from relevant government agencies, lack of communication and the necessary analysis of the economic and financial condition of water management and reclamation complex – can pose significant problems, lead to ineffective or erroneous decisions [13-15]. In practice, three main inhibitory factors often manifest themselves (Fig. 1).

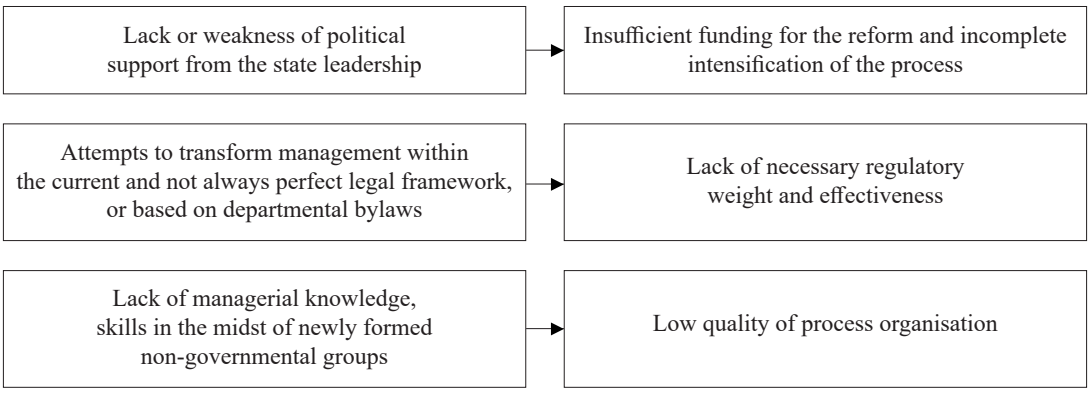

Figure 1. Inhibitory factors of TISM and their consequences for reform
Source: formed by authors based on literature sources [11-13]

To remove existing obstacles and increase the effectiveness of reform processes, it is necessary to comprehensively analyse the current state of government policy and public administration in the field of land reclamation, study the experience of similar reforms in other countries, and identify key principles to be

followed in the reform process to ensure the effect of institutional change considering the likely risks.

It is advisable to refer to the international experience of similar transformations in countries with transit economies, especially post-Soviet, where the remnants of the administrative-command system and technocratic approaches to the development and implementation of public policy have long hindered effective results, delayed and sometimes discredited reforms [14; 22; 23].

Purpose of the article is to study the problems of development and implementation of state policy in the field of land reclamation in Ukraine and the relevant international experience of reforms in the irrigation sector, to identify the vision of the main principles and methods of managing the process of implementation of the Irrigation and Drainage Strategy until 2030.

▸ Materials and Methods

For the first stage, statistical data and publications in electronic media on the use of irrigated lands and water resources of Ukraine were used [24; 25], the results of our own research on the efficiency of irrigation systems in Southern Ukraine [17; 19; 20]. In the second stage, the reports of international organizations (FAO, the World Bank, the International Commission on Irrigation and Drainage, the International Institute of Water Resources Management-IWMI, etc.) were studied [11-13] on the effectiveness of projects to reform and modernize irrigation systems in countries with transit economy (Georgia, Armenia, Tajikistan, Uzbekistan, Kyrgyzstan, Bulgaria, etc.) [14-16]. At the third stage of the research general-scientific and specific methods were used: comparative-historical and monographic methods – to compare and evaluate the information collected in the previous stages of work, and statistical data reflecting the processes of land reclamation reforms in Ukraine and the world. The properties and characteristics of irrigation systems of different sizes and management were compared and evaluated; system analysis – for a comprehensive assessment of the current state of functioning and potential of irrigated agriculture in Ukraine (the use of systems analysis was explained by the complex construction of the studied management facility, which has natural, technical, socio-economic and environmental components and is an open dynamic system).

The main principles of the system approach were implemented in the system analysis: the task of improving irrigation management was formed comprehensively – considering all significant external conditions; the object of study was considered as a system – a hierarchically organised multilevel structure, which includes elements (subsystems), combined direct and feedback – to achieve a common goal for all elements, for example, the maximum number of additional products per unit water. The institutional method assumes that the research focuses on economic institutions, their structures, properties, functions and relationships, including formal and informal institutions (norms, rules, traditions, etc.) on the basis of which these institutions (organisations) operate. Abstract-logical – for theoretical generalizations, formulation of categories and conclusions). The experience of the authors' cooperation with water users (managers and specialists of farms) in the irrigation zone in the South of Ukraine during 2015-2021 was also used.

The above methods and research methodology suggest that the theoretical and methodological principles of improving the management of irrigated agriculture can not be reduced to only one method, because each method is used not in isolation, but in combination with others.

▸ Results and Discussion

Currently, the realisation of the agricultural potential of reclaimed lands in Ukraine is constrained by a significant set of natural, technical, organisational, economic and environmental factors, including:

– the need to modernise the entire water management and reclamation complex, considering the climate crisis, including changes in water and land use conditions and the consequences of deteriorating technical condition of the main water infrastructure;

– reduction of the actual areas of artificial humidification due to the failure of part of the on-farm irrigation and drainage systems and the unsatisfactory technical condition of the infrastructure that continues to be used;

– fragmentation of land use arrays within the technological modules of irrigation systems;

– availability of various forms of ownership of domestic infrastructure;

– rising tariffs for water and electricity, inefficient management of water and energy resources;

– development of soil degradation processes, such as erosion, salinisation, waterlogging, depletion of mineral elements, desertification etc;

– deterioration of human resources in the industry.

To address these issues, and attract investment in the modernisation of reclamation systems, in 2019 the Cabinet of Ministers of Ukraine approved the Irrigation and Drainage Strategy until 2030 [21], and in 2020 – an action plan for its implementation [26]. The documents set out institutional changes in the industry management system, which provide for the transfer of authority (management transformation) for the operation of networks at the lower level to newly established water user associations, and their involvement in management at the regional system level. However, the complicated course of institutional change is still slowing down and not being implemented as a coherent, coherent and interrelated measure with other reforms, which in turn does not increase the efficiency of irrigation and drainage expected by stakeholders. Thus, in 2021, irrigation systems operated on only 25% of potentially irrigated agricultural land. Conditioned upon the low level of development of arable land reclamation systems, Ukraine annually loses at least $ 1.5-2.0 billion in foreign exchange earnings, which is equivalent to almost 10 million tons of unharvested grain harvest. At the same time, the State Accounting Chamber concluded that only by irrigating the entire existing

area of irrigated land, it is possible to increase agricultural production and gross domestic product by almost UAH 8.8 billion [27].

It has become clear that the implementation of the action plan raises a number of issues related to conflicts of interest between different stakeholder groups, including existing traditional methods of communication between government officials and society and water and land users in particular. Thus, separate groups of stakeholders (so-called small water users, representing small farms or using their own land shares; united territorial communities with on-farm reclamation infrastructure and land transferred to community ownership; local environmental NGOs, which deal with conservation of water and land resources, etc.) did not participate in the development and discussion of the draft law on organisations of water users, and therefore have serious comments on the already, unfortunately, adopted by the Verkhovna Rada legislation [28].

Lack of theoretical knowledge and practical experience in carrying out irrigation management reforms creates many misinterpretations and difficulties in communicating initiators of change with society and various groups of water users. The bill received all new proposals and comments, which for a long time continued to be finalised in the working group and the Verkhovna Rada Committee. The most controversial provisions of the law are in the areas of environment, lease and ownership of land and infrastructure, ensuring fairness in management decisions in the interests of all members of the newly formed Water Users Association (WUA) and guarantees of private investment protection. Each of these conflicting moments is related to the interests of a particular stakeholder group, their role and opportunities to influence reform processes.

At the same time, a significant obstacle to successful institutional transformations is the difficulty of creating a new transparent system for the formation and approval of tariffs for water supply and sewerage services. After all, over the last 5 years, tariffs for irrigation and electricity services, conditioned upon the impact of many technical, economic and organisational factors, have been growing steadily. Table 1 shows the growth dynamics of individual costs that form tariffs for water services for users only for water intake from the Kakhovka main canal, and also the cost of services of the district administration of one farm and the Basin management of water resources of the lower Dnieper, which in 2020 reached about 300 and 15 UAH/1000 cubic meters, respectively.

Under such conditions, and against the background of lower prices for agricultural products and rising energy costs, there is a danger of losing the expected profitability of irrigated agriculture. Therefore, it is extremely important to find ways to reduce operating costs through the implementation of measures to save resources, reduce non-productive water losses, optimise general production and other costs of water management organisations. It is important to create preconditions for their constructive dialogue to increase the efficiency of operation of inter-farm systems, improve the quality of services and avoid conflicts between water users and water management organisations (Table 1).

Table 1. Dynamics of costs for the collection and transfer (transportation) of irrigation water by the Department of the Kakhovka main canal, UAH/1000 cubic meters

Year	Cost of water intake	Cost of overturning (transportation), total	Including cost:		Direct costs for payment of labour	Capital expenses for updates and modernisation
			Electricity services	Electric power industry		
2016	145.8	250.8	52.2	198.6	8.3	20.5
2017	179.3	318.2	64.2	254.0	10.8	19.7
2018	245.5	355.6	87.9	267.7	15.0	26.3
2019	314.2	418.8	112.5	306.3	18.3	30.4
2020	314.2	411.5	112.5	299.0	25.4	29.9

Source: formed according to the annual orders of the Kakhovka Main Canal Department (No. 66/1 of 03/03/2016; No. 75 of 03/22/2017; No. 69/1 of 03/01/2018; No. 98 of 03/14/2019; No. 100 of 03/18/2019)

First of all, we need a new system of informing water users based on transparency, involving them in decision-making on the development of water distribution plans and the composition of operational work in some areas of government systems.

Another issue that requires coordination of the interests of different stakeholder groups (land users, landowners and united territorial communities) is the issue of land consolidation within the areas of technological modules of irrigation systems. In many cases, the lease term of landowners' shares does not exceed 5-7 years (based on the results of communication with water land users, managers, hydraulic engineers and agronomists of farms in the area of irrigation systems); however, there are cases when individual landowners do not want to enter into or extend lease agreements with farmers for various reasons. It is known that the average area of land share in the south of Ukraine is 2-4 hectares, while the area of irrigated fields from 60-100 hectares within one irrigated field is located from 15 to 30 or more shares [29]. At the same time, some landowners form their own small farms or work as private farms, and some are waiting for better offers on the amount of rent or sale of land at a higher price. Under such conditions, farms invest their own funds in the restoration and modernisation of irrigation systems only in areas where long-term lease agreements have been concluded with landowners (more than 10-15 years). To solve the problem of undesirable

fragmentation of land use on irrigated lands, it is necessary to coordinate the reform of the irrigation sector with the results of land reform, which will ensure the effective implementation of land consolidation projects along with the establishment of water users.

Thus, it is becoming increasingly clear that in addition to modernising technical infrastructure and creating new organisations to manage irrigation systems, it is urgent to introduce a new culture of communication between stakeholders to form, implement and develop public policy in the field of nature. Existing outdated culturological principles and political and economic tools are the main obstacles to the effective implementation of reforms and implementation of large infrastructure projects. That is, the lack of a proper culture of stakeholder dialogue at the local level, lack of transparency of reform processes at both state and local levels, lack of coordinated intersectoral cooperation and participation in these stakeholder transformations, and underestimation of professional expert support for research and educational institutions for economic substantiation of new models of management of reclamation systems and dissemination of necessary knowledge among all participants of the reform process.

The government's efforts to accelerate reform and move to investment as soon as possible do not work without professional management of institutional change according to good governance standards (transparency, stakeholder participation, efficiency, accountability, interconnectedness) and a clear architecture of a multi-sectoral multi-disciplinary integrated approach.

Analysing the international experience, the answer was sought to the question under what conditions and through what mechanisms it is possible to achieve a balance of state, public and business interests in the implementation of reforms. According to experts from the World Food Programme (WFP), reforming the irrigation sector or transforming irrigation management primarily involves the transfer of management of irrigation systems from government to non-governmental organisations [6]. Beginning in the mid-1970s, governments in many countries began to successfully transfer control of irrigation systems from state water agencies to farmers' organisations or other non-governmental organisations [14].

In countries with transit economies, the post-Soviet republics of Central Asia and the Caucasus, and Eastern Europe, irrigation management reforms began with the transfer of irrigation infrastructure ownership or long-term management to water users, and then (or in parallel) there were changes in the management of the state water management and reclamation complex [19; 10]. Reform processes have been long, complex and very often adjusted or radically changed. As a result of ill-considered political decisions and the dominance of the interests of certain groups of water users or departmental interests of government agencies, numerous mistakes were made.

As a result of studying and in-depth analysis of the world experience of reform in these countries [10; 14; 23] we have established the following general patterns of this process and made certain conclusions that may be useful for Ukraine. Yes, common to all countries was the following:

1. Everywhere, the reform process (since the early 1990s) has been very complex and lengthy, requiring serious expert support from international organisations in drafting legislation and drafting certain provisions of the law in the pilot territories.

2. Organisational models at all levels of irrigation system management have changed and adjusted many times, both at the establishment of the Water Users Association (WUA) and at the level of organisational structures for the management of major canals.

3. Small WUAs were economically incapable everywhere. The best results were achieved in case of creation of powerful associations (from 3000 ha) for the operation of the tertiary (grassroots) irrigation network and pumping stations, as well as their federations for the purpose of operation of secondary distribution channels (Kyrgyzstan).

4. Governments have often made hasty decisions to establish national or regional state-owned companies to manage trunk and secondary distribution channels, which have failed to ensure proper operation of systems and quality of service for water users explained by underfunding of the necessary costs (Armenia, Georgia, Bulgaria). To continue to provide irrigation services, governments were forced to increase government subsidies for these companies, which also did not address the issue of sustainability. To remedy the situation and improve the performance of state-owned companies, they have been restructured so that water users have influence in management decisions, and companies also have the opportunity to conduct business to obtain additional funds to cover infrastructure costs (Armenia, Bulgaria).

5. Reform plans changed when the next government changed, depending on the involvement of international technical assistance and the organisation of investment projects. At the same time, World Bank projects played a significant role in all countries, and in many cases were forced to correct mistakes made by governments at various stages of transformation.

6. The expected progress in the reform was observed after the emergence of quality legislation on the establishment of WUAs, providing financial and advisory support from the state (training, coaching, advisory support, implementation of special government programmes, and access to investment) [4].

7. The existence of a Reform Strategy, the development of an appropriate package of legislation and regulations, a state plan or programmes to implement reforms – all these countries had key conditions for ensuring positive changes in water management and restoration of artificial wetlands.

8. Reforms in irrigation management and the implementation of projects for the reconstruction and modernisation of irrigation systems everywhere were accompanied by the resolution of land issues in terms of consolidation of small land users.

Summarising the results of research [6; 18], the authors of the study note that institutional reform is a process that is constantly improving, adjusting and depends on society's readiness for new democratic decentralised forms of government. The state's

efforts to maintain its influence and its decisive role in management at the level of the main trunk canals are remnants of centralised hierarchical management from the past practice of the Soviet planned economy.

Unwillingness to transparent procedures, weak state institutions and lack of good experience in involving private water users in water infrastructure management are what all transition economies faced at the beginning of the reform.

At the same time, the countries that joined the European Union had some preferences in the possibility of receiving support from EU programmes. However, as the example of Bulgaria shows, comprehensive support from the EU and international organisations has not saved the country from numerous mistakes and negative consequences of the government's desire to maintain uncontrolled levers of public administration. The creation of a state-owned profitable company resulted in a significant reduction in the potential of irrigated agriculture conditioned upon the complete refusal of some farmers to use artificial moisture when water tariffs increase. A similar pattern was observed at the beginning of the new century in Georgia and Kyrgyzstan.

The main risks in carrying out reforms in irrigation management

All these examples are a warning to the Government of Ukraine and an argument to avoid repeating mistakes that have taken place in other countries. This is especially true of the choice of institutional model for the management of the state share of water infrastructure. Based on the study of the experience of implementing reforms in different countries and the reform process in Ukraine, we have identified the following main risks that should be considered when implementing the provisions of the Irrigation and Drainage Strategy.

1. *Risk of underfunding to cover the costs of operating the main state water management and reclamation infrastructure.* In the case of the creation of a national joint stock company (NJSC) or individual state joint stock companies at the level of main channels, there is a risk that it is impossible to cover operating costs without a significant increase in tariffs and increase government subsidies.

2. *Risk of privatisation of strategic water management infrastructure.* With significant underfunding of water infrastructure, government subsidies can be significantly increased to maintain the proper level of services for water users. In the absence of the necessary public funds, in such cases there is a risk of bankruptcy of a joint-stock state company and transfer of strategic state water infrastructure to long-term concessions or ownership to private companies and investors to overcome the critical situation and continue providing appropriate services to water users.

3. *Risk of tariff increases for water users and their organizations.* In the absence of a mechanism for control by water users and ensuring their direct participation in decisions on the formation and approval of tariffs, there will be a risk of inadequate growth of tariff levels, which will make unprofitable growing most crops under irrigation. With certain jumps in world prices for agricultural products, high tariffs may lead to the complete abandonment of some farms from the use of artificial soil moisture, which will significantly affect the level of operation and efficiency of major systems, reduce farmers' profits and and pose risks to the country's food security in dry years. First of all, it will have a negative impact on small and medium-sized farms, which will lead to the development of large debts and the inability of WUAs to operate in such conditions.

4. Risk of lack of independent impartial control over the activities of state-owned enterprises. The establishment of the NJSC envisages the development of a Supervisory Board for the activities of this state-owned company from representatives of government agencies, including a public council from representatives of WUAs. However, if the Supervisory Board is formed arbitrarily and without legislative participation of representatives of WUAs and other groups of water users in decision-making on the operation of systems, use of investment funds and tariffs, then any other type of so-called control will not be objective and impartial. At the same time, decisions aimed at improving the quality of services, regulating and/or establishing fair tariffs may be made not in the interests of water users.

Vision of the basic principles and methods of implementation of the Strategy

Given the potential problems of implementing the Irrigation and Drainage Strategy in Ukraine, the results of analysis of international experience and possible risks that may arise during the reform of the irrigation sector, we propose a system of principles and methods of reforms that change existing cultural and political – economic principles of regulation:

– ensuring integrated planning and coordination of various types of activities, primarily involving all stakeholder groups in the development of laws and regulations (proposals for amendments to the law on WUAs, laws on the creation of new businesses in public irrigation systems, protection of private investments, development of tariff policy, etc.);

– dissemination of knowledge about new institutions, training of those involved in the development of legislation and regulations, and the maximum number of water users in different regions;

– creation of structures supporting the reforms at the level of relevant ministries and agencies with the involvement of specialists with a sufficient level of training;

– ensuring transparency of the process of policy development and implementation according to the standards of good governance, including monitoring and reporting of responsible institutions on the results of reforms;

– deepening international cooperation in the framework of technical assistance projects to support the proper management of reform processes;

– development and implementation of existing state programs for the implementation of certain measures concerning economic and organisational reforms in the water management and reclamation complex of Ukraine;

– establishment of feedback links between the

government, water and land users and communities to inform the public and stakeholders, the introduction of a permanent dialogue of government agencies with stakeholders and the public;

– ensuring comprehensive interdepartmental cooperation by organising inter-ministerial coordination councils with the active participation of leading experts in the field of specialised knowledge;

– development of a "pool" of experts from various scientific and educational institutions for permanent specialised consultations of the government.

▸ Conclusions

The results of the study suggest that today, for the successful implementation of the State Strategy for Irrigation and Drainage in Ukraine, it is necessary to ensure a balance of interests of all stakeholders in the restoration and development of irrigated agriculture. At the same time, it remains important to regulate the implementation of reforms according to the standards of good management and administration recognised by experts. At the same time, social culturological transformations, improvement of feedback, coordination of relations in order to avoid conflicts, prevention of possible challenges and risks are ripe. In view of this, the recommended principles and methods of implementing measures to implement the Strategy, in our opinion, will ensure constructive cooperation of stakeholders at all levels of government, both on the transfer of WUA management and consolidation of land shares in irrigated land, and attracting investment to modernize irrigation infrastructure.

It is established that the dissemination of best international irrigation experience in creating and building new governance structures involving water users, adapting it to the current conditions of Ukraine will allow stakeholders to avoid uncoordinated actions, incorrect or arbitrary interpretation of laws and regulations, prevent unreasonable political decisions in the process of reform. Creation of supporting structures at the level of state institutions with the involvement of relevant specialists and scientists, organisation of exercises and trainings, dissemination of knowledge, development of the necessary favourable environment for quality managerial transformations will allow to successfully complete large-scale restoration and innovative modernisation of water reclamation in the country.

Promising directions of research development in this topic will require: scientific substantiation of the implementation of certain statutory provisions regulating the activities of newly established water user organisations as corporate structures; development of normative documents ensuring their full-scale functioning as economic agents; improving the tariff policy of the cost of providing them with water management services; assessments of the effectiveness of irrigated agriculture in the context of climate crisis and limited water and energy resources; analysis of the effectiveness of pilot projects for the creation and development of WUAs and their associations in the new political and socio-economic conditions of irrigation regions. The results of the study can be used by the Ministry of Agrarian Policy and Food of Ukraine, the Ministry of Environment and Natural Resources of Ukraine, the State Agency of Water Resources of Ukraine, and its regional divisions, working groups at ministries involving agricultural and water users, scientists and educators.

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Імплементація стратегії зрошення та дренажу: політико-економічні та культурологічні аспекти

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► **Анотація.** Стаття присвячена актуальним проблемам проведення інституційної реформи для залучення інвестицій у модернізацію та відновлення зрошувальної інфраструктури та забезпечення покриття витрат на її експлуатацію. Для вирішення зазначених проблем у 2019 році Кабінетом Міністрів України було затверджено Стратегію зрошення та дренажу до 2030 року та у 2020 році відповідний план дій щодо її впровадження. Однак, процес реформ затримується внаслідок наявності системних екологічних, економічних та культурологічних проблем, що створюють перешкоди на шляху перетворень, насамперед, щодо розробки та прийняття законодавства регламентуючого порядок утворення та функціонування нових інституційних утворень (організацій водокористувачів та структур управління державними меліоративними системами й ін.). Мета статті полягала у викладенні результатів аналітичних досліджень з вивчення українського та міжнародного досвіду проведення реформ в управлінні зрошенням та оцінки імовірних ризиків, що можуть виникати на цьому шляху та формуванні бачення щодо управління процесом впровадження Стратегії зрошення та дренажу до 2030 року. Дослідження виконано за допомогою наступних методів: системного аналізу функціонування сектору зрошення в Україні; порівняння (визначення властивостей та характеристик на основі зібраної інформації та статистичних даних про процеси реформ у галузі меліорації земель в Україні та світі), абстрактно-логічного (теоретичні узагальнення та формулювання категорій та висновків. Проаналізовано існуючі процеси реформування у галузі меліорації земель в Україні, зазначено, що за умов ринкової економіки, результативне утримання та розвиток водогосподарсько-меліоративного комплексу може відбуватись лише за партнерства держави та приватного сектору. В результаті досліджень українського та міжнародного досвіду запропоновано принципи й механізми ефективної реалізації трансформацій в управлінні зрошенням та враховують соціально-економічні та культурологічні аспекти процесів реформування в Україні та імовірні ризики, що випливають з аналізу міжнародного досвіду. Надані конкретні рекомендації щодо управління процесом реформування. Застосування запропонованих методів проведення реформи забезпечить залучення інвестицій у модернізацію й відновлення водогосподарської інфраструктури та у подальшому стале використання зрошуваних земель

► **Ключові слова**: меліорація земель; водогосподарсько-меліоративний комплекс; інтегроване управління; інституціональна реформа; трансформація в управлінні зрошення; організації водокористувачів; інвестиції

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