UDC 631.1:631.92

State and perspectives of evolution of agrarian production in Forest-steppe in conditions of climate fluctuation

Tarariko Yu.[1], Soroka Yu.[2], Saydak R.[3], Luka-shuk V.[4]

Institute of water problems and amelioration of NAAS, Vasylkivska Str., 37, Kyiv, 03022, Ukraine; e-mail: [1]urtar@bigmir.net, [2, 3]agroresurs@ bigmir.net, [4]vita_lukashuk@ukr.net

The purpose. To analyze on an instance of administrative area typical for Forest-steppe features of modern most spread practice of agrarian production, to justify directions of interbranch optimization with the purpose of cardinal heightening profitableness of industrial activity. **Methods.** Assessment of changes of agrometeorological resources of terrain was realized by method of mathematical-statistical analysis, data of Goskomstat was treated by methods of system generalization, correlation, economic, settlement-relative analysis. Study of perspective directions of evolution of agrarian production was realized by method of multivariate imitative computer simulation. **Results.** As a result of climatic changes the forest-steppe part of Kiev area has passed from zone of sufficient into zone of insufficient humidification with deficiency of annual water balance — 100 mm. Average for 8 years productivity of grain grains makes 3 – 4 t/hectare, corn for grain — 9, soya bean, sunflower, winter rape and buckwheat — 2, sugar beets — 52 t/hectare with fluctuation on years 20 – 60%. Correlation between indexes of the cost price, the price of implementation and productivity of the crops, specifying on presence of the factors bounding net profit at a certain level are established. Profitableness on an average on years to the level for corn for grain makes 305 c.u./hectare, buckwheat — 243, sunflower — 235, winter rape — 199, sugar beets — 193, soya bean — 173, pease — 100, cereal grains — 60 – 115 c.u./hectare. The highest net profit for 1 hectare of arable land in the area for 8 years attained 324 c.u./hectare, the lowest — 45 c.u./hectare with an average on years index of 189 c.u./hectare and fluctuation concerning it of 42%. To cardinally raise economic efficiency of agrarian production in the area is possible by development of its branch structure on biopower basis. At this situation in uniform technological complex for 1 hectare of arable land they may produce 2 t of vegetable products, 0,8 — sugar, 0,2 — vegetable oil, 0,3 — fibers, 1 t — meat-and-milk products, 1,3 thousand m^3 — gas-methane. It also leads to creation of closed cycle of macro- and microelements with cutting of net cost of production on 50% and heightening of the net profit up to 8 thousand in c.u./hectare. **Conclusions.** As a result of climatic changes in forest-steppe part of Kiev area aside aggravation of conditions of humidification they registered fluctuation in productivity of cultivated crops on 20 – 60% from average. Fluctuation of net profit in administrative area typical for region for 8 years made 45 – 324 c.u./hectare with average on years index of 189 c.u./hectare. Cardinal heightening of profitableness of plowlands of the area up to the level of 8 thousand c.u./hectare may be ensured with transition to principles of biopower agrarian production by building association of agricultural factories and engaging of investment resources.

Key words: *agrometeorological resources, disposition of sown area, fluctuation of productivity, net profit, biopower system of production, association of factories.*

DOI: https://doi.org/10.31073/agrovisnyk201906-08

In the process of reform, the agrarian sector of Ukraine's economy has undergone significant changes. As a result of disintegration of agricultural land, the sectoral structure of agrarian production, the structure of crop areas and the composition of land users have changed significantly [1]. Thus, as of 1987, the arable land amounted to 32.2 million hectares with the number of agricultural enterprises, mainly kolkhozes and state farms, 11.9 thousand and their average area was 2,700 hectares [2]. In 1994, 3.9 million hectares of arable land were transferred to the citizens for farming, private farming, collective and

individual gardening; the number of collective farms increased to 15.1 with an average area of arable land of 1916 hectares [3]. As of 2017, the arable land in Ukraine, excluding the Crimea, amounts to 31.3 million hectares, of which almost 19.3 million hectares were allocated to agricultural enterprises with an average size of 423 hectares. The large dispersal of farms by form of ownership, legal form, size, specialization and other features does not allow to fully realize the potential of economic efficiency of agricultural production [4-6]. Such a situation necessitates the creation of mechanisms for the cooperation of agricultural enterprises in a single production system of high profitability.

The purpose of the research - on the example of a typical administrative district in the forest-steppe part of the Kiev region. to analyze the features of modern widespread practice of agrarian production, to substantiate the directions of inter-sectoral optimization, to offer the organizational form of inter-economic integration for a radical increase in the profitability of production activities. Research methods. Long-term evaluation of changes in agrometeorological resources was carried out on the basis of values of hydrothermal coefficient (GTK), coefficient of humidification (Kh) and climatic water balance (KWB) [7, 8].

Hydrothermal coefficient is defined as the ratio of precipitation to the sum of air temperatures higher 10ºC:

GTK = R/0,1 T,

where R — amount of precipitation (mm) for April - September; T — amount of air temperature (° C) for April - September.

The coefficient of humidification is defined as the ratio of annual precipitation to annual potential evaporation:

Kh = R/ Ep,

where R — annual amount of precipitation, mm; Ep — potential evaporation per year, mm.

Climatic water balance is calculated as the difference between the total amount of precipitation and the potential evaporation for a defined period:KWB = R– Ep.

Using the GTK, Kh and KWB indicators, they compared the changes in climatic conditions between 1961-1990 and 1991-2016.

To determine the promising ways of developing modern agrarian production systems within the administrative district, data from the State Statistics Committee were used, which were processed by generally accepted methods of system analysis: correlation-regression, economic, calculative-comparative. The development of perspective scenarios for the development of the agro industrial complex of the district was carried out by the method of multivariate simulation computer modeling with the help of the software complex "Agroecosystem" [9]. It is precisely on the basis of elaboration of promising models of the industrial structure of the agro industrial complex with a high level of utilization of the available agro-resource potential of the territory and high efficiency of diverse economic formations is achieved [10, 11].

Research results. As of 1994 in the Kyiv region, the arable land amounted to 1170 thousand hectares in terms of the number of landowners and land users of 742 and an average area of 1,577 hectares. In 2016, these indicators amounted to 1100 thousand hectares, 1966 units and 560 hectares of arable land respectively. In the Typical for the Right Bank Forest-steppe district of Kyiv region, as of 1987, 23 agricultural enterprises with an average area of 3174 hectares accounted for 72 hectares of arable land. In 2017, there were 179 agricultural enterprises on the arable land, including 9 private enterprises, 5 state enterprises, 13 companies, 2 production cooperatives, 5 joint-stock companies, 145 farms with an average area of arable land of 290 hectares. The number of cattle was 1432 head, including cows - 595 head of sheep and goats - 250 heads, pigs - 150 heads, horses - 20 heads. That is, the specialization of the area can be considered a crop.

The overall dynamics of the average annual air temperature in the region from 1961 to 2017 was 7,7-9,8oC. During the years 1961-2017, the dynamics of annual precipitation was practically unchanged, but the amount of precipitation in the summer decreased by 34 millimeters, in the autumn - it increased by 21 millimeters. Due to the increase of the thermal regime and the reduction of precipitation in the summer

months, the conditions of humidification of the growing season, expressed by the hydro-thermal coefficient of April-September, deteriorated from 1.34 (sufficient moisture) in 1961-1990 to 1.20 (insufficient moisture) in 1991- 2017 gg. At the same time, the frequency of repetitions of arid phenomena increased significantly. If in 1961-1990 there were no very dry conditions, and the average dry land was observed at a frequency of 10%, then in 1991-2017 7% of the cases were very dry conditions and 11% were medium-dry. The deterioration of humidity in global and regional warming is also indicated by an increase in the deficit of climatic water balance (CWB). The total dynamics of the total for the year of the KSB from the first half of the 80-ies of the last century is directed towards the reduction from deficit to - 100 mm. At the same time, the duration of the period with positive values of CVB during the year significantly decreased. If in 1961-1990 positive KWB was observed by the end of July, then now only by the end of May. Under these conditions, the zonal level of water supply has changed. If in 1961-1990 the region of research on climatic water balance belonged to the wet zone, now - to insufficiently moist. Consequently, in the conditions of the district, the risks of creating unfavorable conditions for the cultivation of all crops and the inefficient use of agro-resources have increased significantly (Table 1).

According to the average indicators of 2009-2017, the largest share in the structure of the crops area is soybean - 25%, corn - 20 and winter wheat - 18%. Sugar beet and sunflower respectively occupy 9 and 8%, wheat and spring barley - 7 and 6%. That is, the enterprises of the district for the most part use the following crop rotation: 1 - cereal spike (wheat, barley); 2 - bream (corn, sugar beet, sunflower); 3 - leguminous and cereal (soybeans, peas, buckwheat). This testifies to the observance of scientifically grounded alternation and the timing of the return of crops to the previous place of cultivation. The main factor determining such a structure of sown areas and crop rotation is the desire to increase the profitability of production. This indicator is determined by crop yields, production costs and sales prices. Regarding average yields grown in the area of crops (Table 1), it should be noted its relatively low level and significant change over the years to the average indicator for variable agrometeorological factors: from 20% in sunflower to 60% in rabbit rape. There is a clear tendency to increase productivity of all cultivated crops except legumes.

1. Productivity of crops and its variability in 2009-2017.

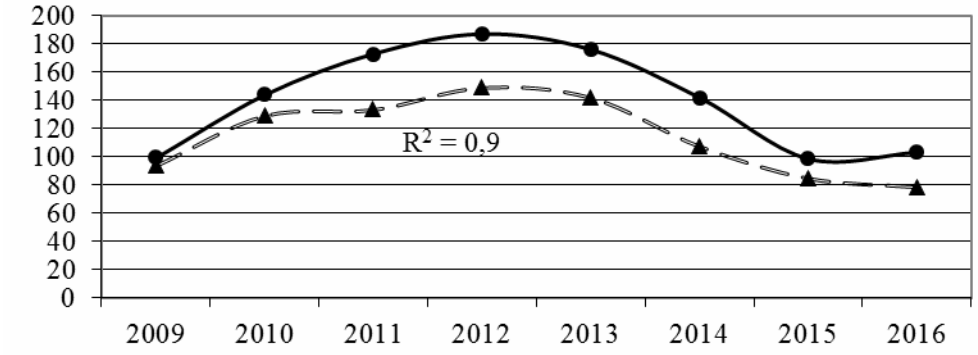
Culture	Yield, c / ha			Variability coefficient,%
	minimum	maximum	average	
Winter wheat	23,6	59,9	43,9	27
Wheat Yara	24,5	57,7	38,4	33
Winter barley	11,0	51,3	26,6	48
Barley is springy	23,9	46,2	32,7	29
Pea	15,1	33,1	24,8	25
Buckwheat	14,1	23,3	17,8	23
Corn for corn	67,1	145,4	92,5	36
Winter Rape	6,2	31,9	19,8	38
Rape is overcast	5,8	29,1	11,5	61
Sunflower	15,8	25,7	20,7	20
Soy	13,2	25,8	19,6	24
Sugar beets	335,2	769,6	515,8	33

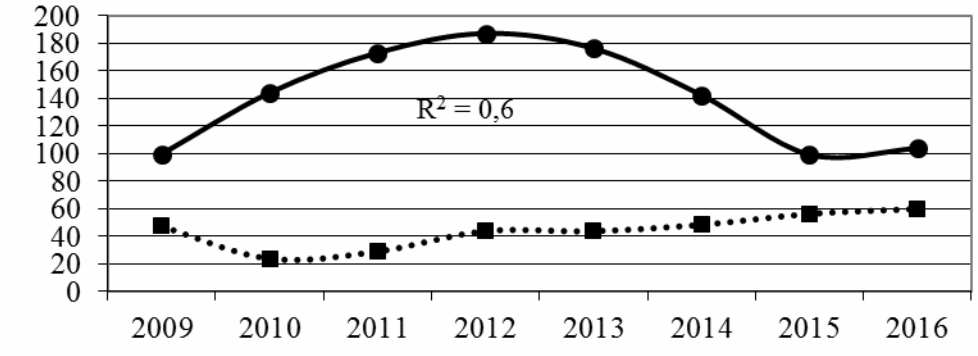
The changes in production costs over the years, depending on the culture, make up 30-50%, and the highest is the cultivation of sugar beet - an average of 1900 conventional units per hectare, the lowest - winter barley - 270 c. u. per hectare, with an average of 600 conventional units per hectare. Changes in sales prices over the years from the average perennials depending on culture make up 20-30%. According to this indicator, products of all crops except legumes tend to decrease.

These indicators are related (Figure 1). So, let's say, the value of the reliability of the approximation between the cost price and the sale price of wheat winter wheat $R^2 = 0,9$. This indicates that the reduction in the cost of grain necessarily accompanied by a reduction in the price of its implementation. Similar regularities are established in other cultures. That is, regardless of the results of production activity, all agricultural enterprises are limited in increasing profitability at a certain level.

As changes in sales prices, crop yields and production costs over the years, net profit also varies significantly. The greatest risks associated with the cultivation of barley, peas, buckwheat, rape, and sugar beet (Table 2) are associated with unprofitable results. This is especially necessary to take into account those who spend crop rotation not in space, but in time.

The most profitable in the middle of the year was the level of: corn for grain - 305 c. u. / ha, buckwheat - 243, sunflower - 235, winter rape - 199, sugar beet - 193 c. u. / ha, soybeans - 173 with average for years and crops profitability of 152 c. u. / ha. In such a crop rotation with the same area of these crops, the average net profit from 1 hectare will increase to 225 c. u. / ha.





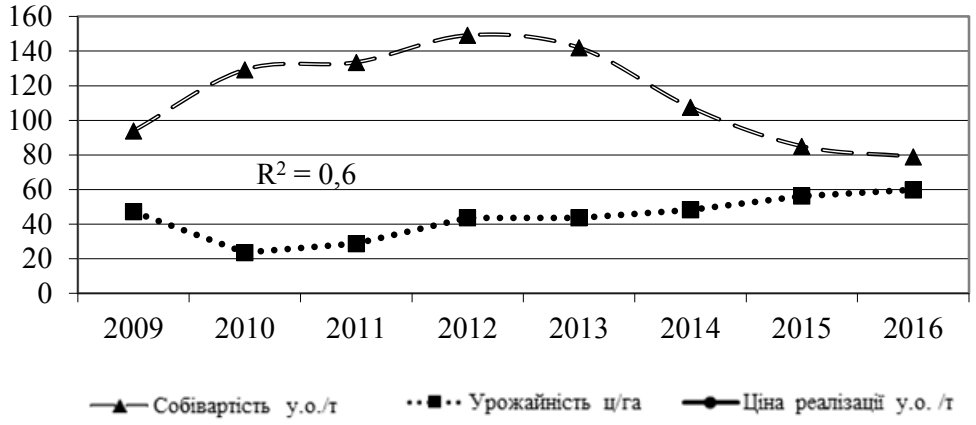


Figure 1. Dependence between the sale price, cost and yield of winter wheat grain

200 180 160 140 120 100 80 60 40 20 0
Year2009 2010 2011 2012 2013 2014 2015 2016
R^2=0,9 R^2=0,6 R^2=0,6

The actual crop area grown in the crop area is different, correspondingly, the highest actual net profit achieved in 2011 is 324 c. u. /ha, the lowest was obtained in 2009 - 45 c. u. / ha with an average over the years indicator 189 c. u. /ha and a deviation of 42% (Figure 2). In the case of removing from the structure of the crop area of the region the least profitable grain cereal, occupying about a third of the crop area, net income may potentially increase from 189 to 228 c. u. /ha. Consequently, the analysis of current widespread practice has shown high instability of its results over the years and the presence of factors limiting net profit at a certain level.

2. Profitability of crops and its variability in 2009-2017

Culture	Net profit, c. u. /ha			Coefficient of variation,%
	average	maximum	minimum	
Wheat: winter	115	202	27	43
Wheat Yara	99	302	32	67
Barley: winter	70	128	–7	45
Barley is springy	58	156	–22	63
Pea	98	360	–1	73
Buckwheat	243	645	–9	62
Corn for corn	305	529	21	42
Rape: winter	199	320	89	38
Rape is overcast	43	267	–57	84
Sugar beets	183	1000	–161	82
Sunflower	235	352	125	33
Soy	173	265	81	35

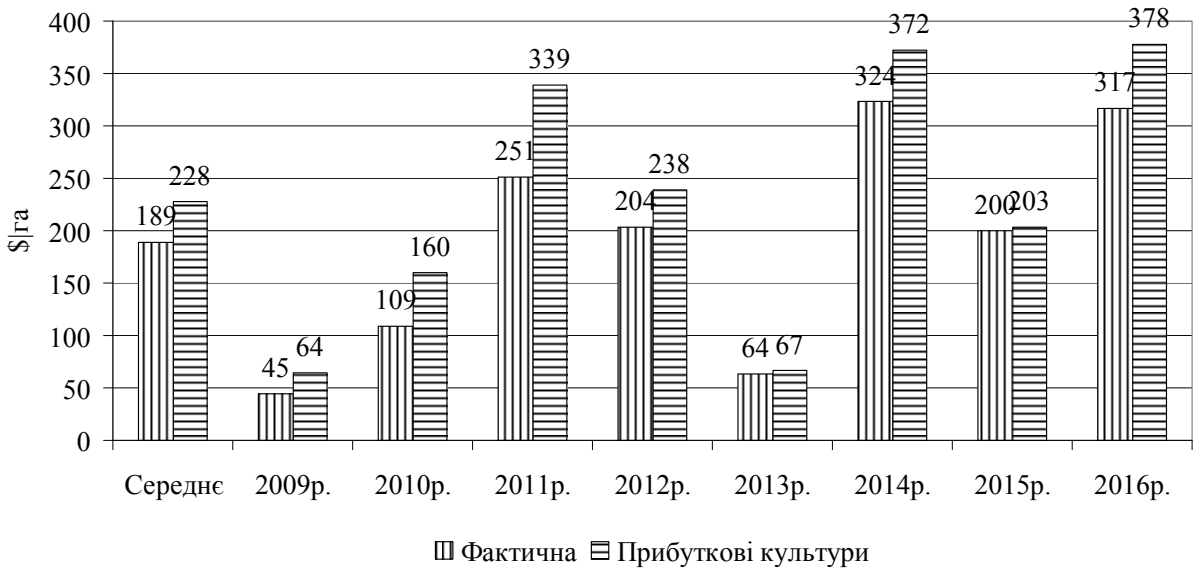


Figure 2. Dynamics of net profit per hectare of arable land for the actual and prospective structure of the crops area: - actual profit; - promising profit

dollars US / ha 400 350 300 250 200 150 100 50 0
Yearaverage 2009 2010 2011 2012 2013 2014
2015 2016
189 228 45 64 109 160 251 339 204 238 64 67 324
372 200 203 317 378

The economic efficiency of agricultural production in the region can be dramatically improved due to the development of its sectoral structure, in particular on the bioenergy basis. The creation of a diverse production system allows one hectare of arable land to receive more than 1 ton of sugar, 0.2-0.4 tons of vegetable oil, 1.0-1.5 tons of ready-to-eat meat and dairy products, at the same time, 0 , 3 t / ha of fiber, up to 1.5 thousand m^3 of methane gas or 5.5 thousand kWh of "green" electricity, 6.5 thousand kWh of heat energy, to reduce CO_2 emissions to the atmosphere by 8-10 t and ensure the employment of the rural population. Preliminary calculations with the help of special software made it possible to estimate the expected production and economic indicators in the first approximation in the case of the formation of such a system on the basis of agricultural enterprises of the district (Table 3).

3. Expected production and economic indicators of the district

Indicator		Value
Area of arable land, ths ha	Total	42
	Cereals	32
	fodder	10
Yield, t / ha	Cereals	6,2
	fodder	52,0
Livestock, thousands of goals	Cattle	100
	cows	50
Productivity on milk, thousand kg per year		10
Fat milk,%		3,5
Losing weight, kg	Extreme cows	525

	Bugaytsev	372
Entrance, %	Meat (without offal)	40
	Passes into dry manure biomass	50
	Biogas from dry manure	45
Output, kWh	Electricity from 1 m^3 of biogas	2,4
	Heat energy from 1 m^3 of biogas	2,8
Recycling,%	Nitrogen	75
	Phosphorus	91
	Potassium	99
The balance of humus (organic carbon), %		176
Costs to,%	The maintenance of animals from the cost of feed	150
	Recycling from cost	20
Economic indicators, c. u./ha	Capital expenditures	10000
	Gross income	12000
	Production costs	4000
	Net profit	8000
	Cost of meat and dairy products	1
Payback period, years		2

In contrast to the purely plant-based specialization, the formation of a multisectoral system makes it possible to significantly reduce or eliminate the influence of negative agrometeorological factors on the efficiency of agrarian production. In particular, the bioenergy sector structure involves the own processing of soy, sunflower, rape and beet sugar to produce oil and sugar. Shrot and molasses are used for the production of mixed fodders, and the fresh pulp, which is obtained at its own sugar factory, for 9 months. and more directly feed animals. In unfavorable fodder crops years are used insurance reserves of hay, hay and silage, in favorable - the reserve stocks of main feed are replenished. In the unfavorable for grain cereals, corn, soybeans, sunflowers or rape years, at high purchasing prices, grain surpluses are realized using feed stocks. In favorable years, when purchasing prices are reduced, the grain is processed into feed and used to produce livestock products.

One of the main advantages of such a transformation is a substantial reduction of the cost of industrial resources at the expense of its own sources of energy, minimizing the use of mineral fertilizers and reducing the cost of pesticides due to the disinfection of all waste in biogas plants and the introduction of crop rotation with optimal precursors. As a result, the cost of livestock products is formed at the level of 1000 c. u. / t. It is also assumed that for the achievement of high quality in the system of organic production with a minimum cost of agrochemicals, the resulting products will be implemented under the "organic labeling". Net profit may reach the level of 8 thousand c. u. / ha with the payback period of capital expenditures 2-3 years. The high profitability of the project enables to dynamically develop a bioenergy infrastructure without the involvement of external financial resources.

However, such a reorientation of the agro-industrial complex of the district will not take place on its own. This process requires sufficient financial support and effective organizational and legal mechanisms for the unification of a large number of diversified agricultural enterprises with a different form of ownership. The first component, involving the attraction of 400-420 million c. u., can be provided with the interest of potential investors in the rapid recoupment of capital expenditures, high quality and competitiveness of the products obtained with a strategic perspective of active development of domestic and international markets for agricultural products. The second component can be provided by the creation of associations of enterprises of the district - a system of enterprises, united by sectoral,

territorial or other principles in order to coordinate activities, ensure the protection of their rights, representing common interests in public or other bodies, as well as in international organizations. According to the agreed decision of the enterprises, the centralized implementation of separate production-economic and other functions with the determination of the rights and responsibilities of the management apparatus on the basis of the voluntarily delegated by him enterprises may be entrusted to the association. The founding documents of the association are the constituent agreement, signed by its members, and the statute approved by them.

Conclusions

In the years after the land reform, the average size of agricultural enterprises has decreased by an order of magnitude. As a result of climatic changes in the direction of deterioration of moisture conditions, the growth of the variability of the yield of cultivated crops to 20-60% of the average is noted. The highest actual net profit in the region for 8 years was 324 c. u./ha, and the lowest was 45 c. u./ ha, with an average of 189 U.D./ha, and a 42% decline in relation to it. The radical increase in the profitability of arable land in the region is ensured by the transition to the principles of bioenergy agrarian production through the creation of an association of agricultural enterprises and the attraction of investment resources.

References

1. Lupenko Yu.O., Sabluk P.T., Mesel-Veseliak V.Ia., Fedorov M.M. (2014). Rezultaty i problemy reformuvannia silskoho hospodarstva Ukrainy [Results and problems of reforming Ukrainian agriculture]. Ekonomika APK [APK economy]. № 7. pp. 26 – 38. [in Ukrainian].

2. Nalichie i raspredelenie zemelnogo fonda v Ukrainskoy SSR (1987) [The presence and distribution of land in the Ukrainian SSR]. Kiev: GOSAGROPROM USSR. Upravlenie zemlepolzovaniya i zemleustroystva. 99 p. [in Russian].

3. Derzhavnyi zemelnyi kadastr Ukrainy (1994) [State Land Cadastre of Ukraine]. Kyiv: Derzhavnyi komitet Ukrainy po zemelnykh resursakh. 179 p. [in Ukrainian].

4. Voloska V.V. (2007) Efektyvnist vyrobnychoi diialnosti fermerskykh hospodarstv [Efficiency of production activity of farms]. Ahroinkom [Agroincom]. № 11. pp. 37 – 42. [in Ukrainian].

5. Skoruk O.P., Zubar I.V. (2013) Efektyvnist fermerskykh hospodarstv Ukrainy v aspekti rozmiriv yikh zemlekorystuvachiv [Efficiency of Ukrainian farms in terms of the size of their land users]. Universytetski naukovi zapysky [University research notes]. № 2. pp. 209 – 218. [in Ukrainian].

6. Mesel-Veseliak V.Ia. (2008). Optymalni rozmiry silskohospodarskykh formuvan promyslovoho typu v Ukraini [Optimal sizes of agricultural formations of industrial type in Ukraine]. Ekonomika APK [APK economy]. № 3. pp. 13 – 20. [in Ukrainian].

7. Georgeta B., Remus P. (2015). Climatic water balance dynamics over the last five decades in Romanias most arid region, Dobrogea. J. Geogr. Sci. № 25(11). pp. 1307 – 1327.

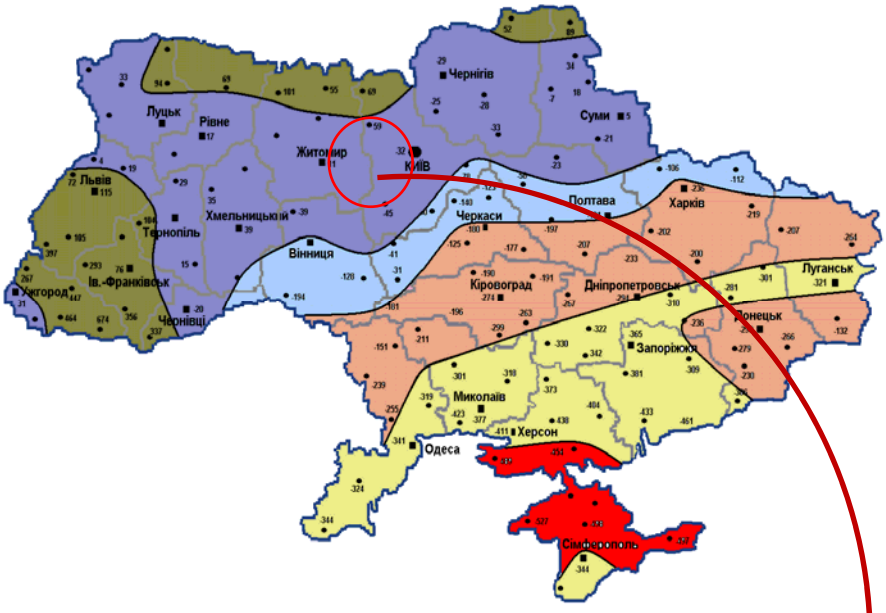
8. Meliorovani ahroekosystemy (2017). [Reclaimed agroecosystems]. Nizhyn: Vydavets PP Lysenko M.M. 696 p. [in Ukrainian].

9. Rozrobka gruntozakhysnykh resurso- ta enerhozberihaiuchykh system vedennia silskohospodarskoho vyrobnytstva z vykorystanniam kompiuternoho prohramnoho kompleksu: rekomendatsii [Development of soil protection resource and energy saving systems for agricultural production using a computer software system: recommendations]. Kyiv: Nora-Druk, 2002. 122 p. [in Ukrainian].

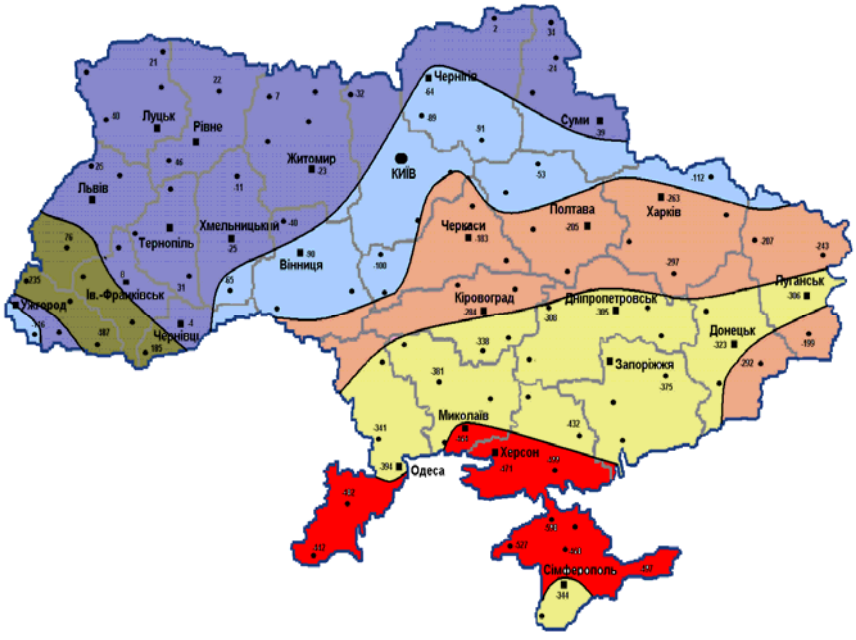
10. Tararyko Yu.A. (2007) Formyrovanye ustoichyvыkh ahroэkosystem [Formation of sustainable agroecosystems]. Kyiv: DYA. 560 p. [in Ukrainian].

11. Tararyko Yu.O. (2011). Enerhozberihaiuchi ahroekosystemy. Otsinka ta ratsionalne vykorystannia ahroresursnoho potentsialu Ukrainy: rekomendatsii [Energy saving agroecosystems. Assessment and rational use of Ukraine's agro-resource potential: recommendations]. Kyiv: DIA, 576 p. [in Ukrainian].

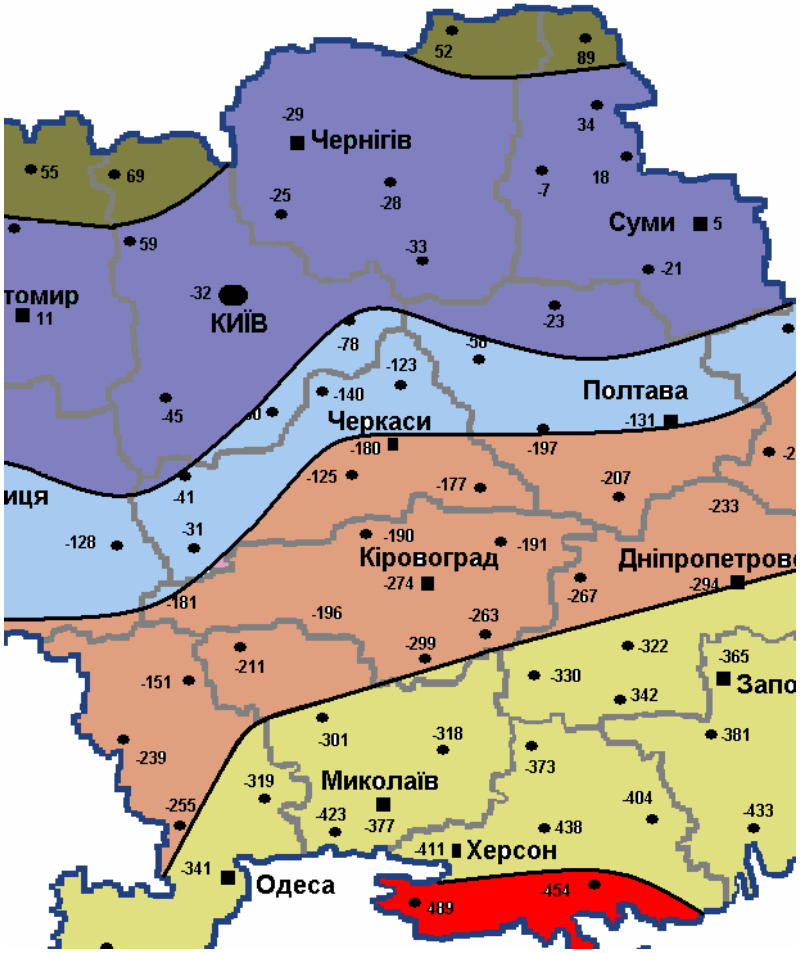
Changes in humidity conditions of the territory of Ukraine in terms of the annual climatic water balance (difference between the annual amount of precipitation and potential evaporation)

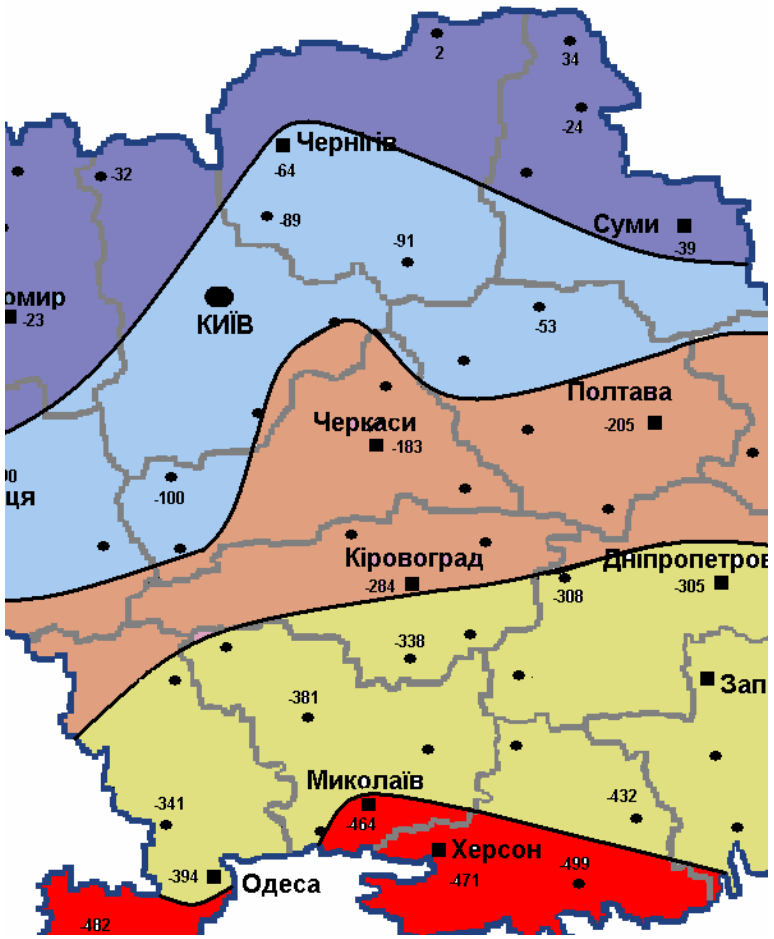


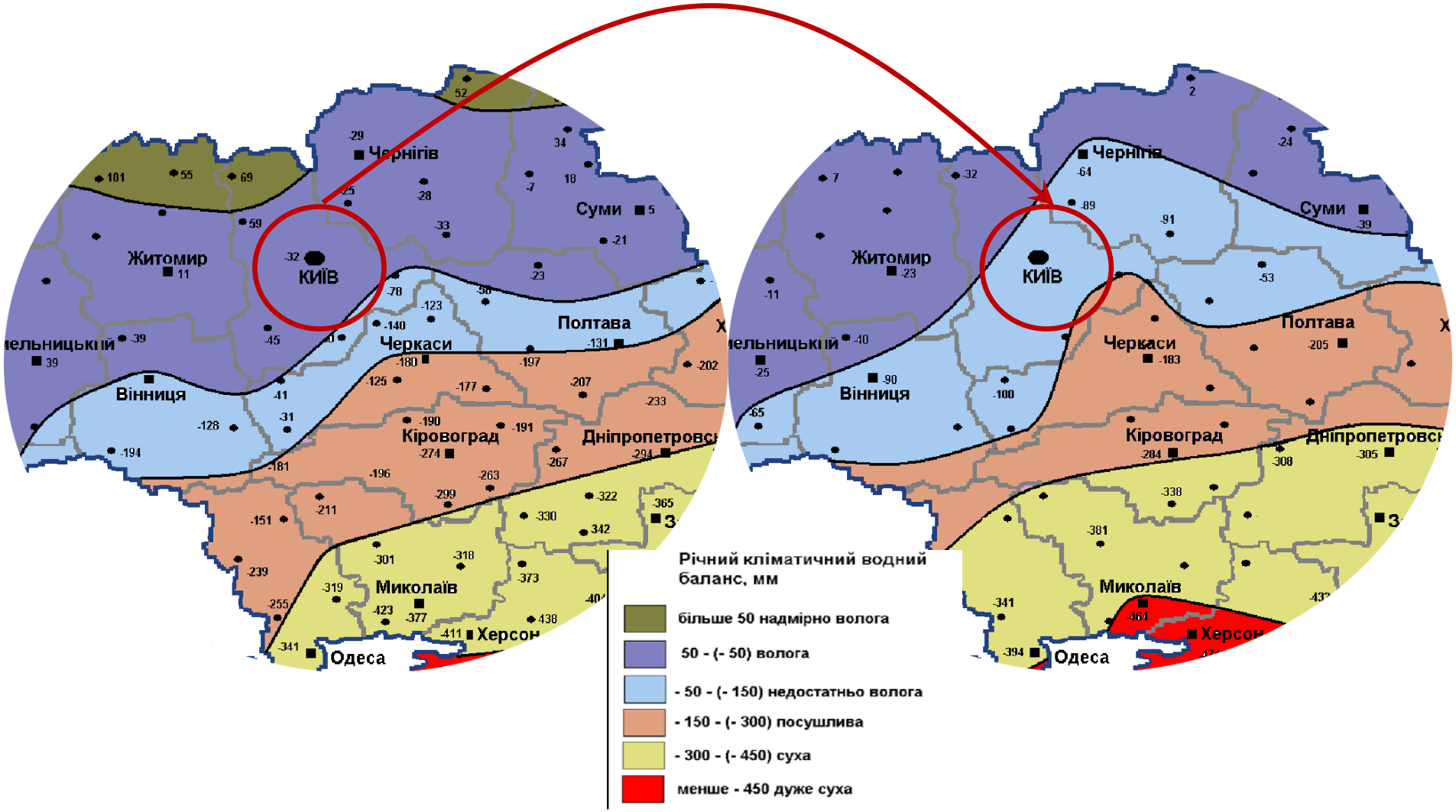
1961–1990 рр.



1991–2016 рр.


52
89
-29
Чернігів
34
55
69
18
-25
-28
-7
Суми
5
59
-33
-21
-32
КИЇВ
11
-23
-78
-56
-123
-140
Полтава
-45
Черкаси
-131
-180
-197
-125
-177
-207
-233
-41
-31
-128
-190
-191
Кіровоград
Дніпропетров
-274
-294
-181
-267
-196
-263
-299
-322
-365
-211
-330
342
-151
Запо
-301
-318
-381
-239
-373
-319
Миколаїв
-404
-255
-423
-377
438
-433
-411
Херсон
-341
Одеса
-454
489


2
34
-24
Чернігів
-32
-64
-89
-91
Суми
-39
КИЇВ
-23
-53
Полтава
Черкаси
-205
-183
-100
Кіровоград
-284
-308
-305
-338
Зап
-381
Миколаїв
-341
-432
-464
Херсон
-499
-394
Одеса
-471
-482



Changes in the humidity conditions by the annual climatic water balance of the territory of Ukraine (the difference between annual precipitation and potential evaporation)