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NATURAL AND CLIMATIC CONDITIONS AS A RISK FACTOR FOR AGRICULTURAL PRODUCTION IN UKRAINE

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Abstract

The main objectives of the study: to assess the impact of changes in the natural and climatic conditions on the functioning of the agricultural sector in Ukraine; to substantiate the classification of management levels of aggregate economic risks in agrarian business taking into account agroclimatic zonal affiliation; to develop a system of insurance for climate risks.Climate change poses an increased risk for people, capital (economy) and the environment. Risk assessment from climate change is one of the most important bases for any adaptation strategy, because it can help program developers to select and implement the best solutions. While risk assessment is not a new concept and it is constantly used in various socio-economic sectors, the assessment of the risks from climate change is still something unusual.That is important the study of natural and climatic risks and their impact on agricultural production is relevant.

Keywords: *agricultural production, atmospheric precipitation, cclimate change, climatic zones,greenhouse gas emissions, temperature regime*

JEL classification: *Q 12, Q 54*

1 Introduction

The peculiarity of agrarian production is that it is carried out under auspicious, under the conditions of a not-for-profit period and production period, a tangible dependence of the industry on natural, regional, economic, transport, property and other features.

The assessment of the risks of climate change intended to identify the threats that may or may be aggravated by climate change, and to assess their likelihood and consequences in order to properly respond to these threats and reduce their risks. The risks caused by climate change are not static, but rather changeable over time, depending on changes in population size, land use and economic growth or decline. In addition, risks vary in space and have different implications.

According to T. Adamenko, there is a high probability that global warming will lead to deterioration of climatic conditions for 2 million hectares of land. In today's warming and virtually unchanged rainfall, in 10-15 years, part of the territory of Ukraine may become unfit for agriculture (part of the Zaporozhye, Kherson, Mykolayiv and Odessa regions) [5]. According to Ya. Didukh, the cause of climate change is the disturbance of the energy balance of the biosphere and its components - the natural types of ecosystems that arise under the influence of large-scale action of a powerful anthropogenic factor [6]. M. Romaschenko proposed and theoretically substantiated a new methodological approach to the formation of water-saving, environmentally safe irrigation regimes, developed scientific and normative-methodical principles of the organization and conduct of ecological and land reclamation monitoring of irrigated lands, a new concept of protection of agricultural land and rural settlements from flooding, flood and flooding processes [8]. The main reasons for the low returns of land potential in Ukraine are landlessness, lack of a real owner, a false strategy of maximizing land use for cultivation, imperfect machinery and technology for land cultivation and agricultural production, unmatched price policy, non-compliance with scientifically sound farming systems, L. Didkovska [9]. Development of many phytophagous insects is closely related with host plant phenology Bale et al. [10] that is mainly regulated by temperature conditions in the environment. The same factor, such asaverage temperature increase, can influence differently on plants and phytophagous insects. Examples of negative influence of climate changes are described, e.g. resulting from disruption of synchronisation of important processes occurring at different trophic levels of the ecosystem. But the research remains poorly assessment of the level of natural and climatic factors taking into account the regional aspect.

2 Data and Methods

During the research were used statistical data from the State Statistics Service of Ukraine (data from 1995), the State Hydrometeorological Center of Ukraine (data from 1900), methodological publications and annual reports of Eurostat, Ministries and departments of Ukraine (data from 1991), own results of scientific researches of the author, reference and information publications, Internet resources, etc. In the process of research, the following methods of scientific knowledge were used: logical-analytical methods, in particular methods of analogy and comparison, induction and deduction, scientific abstraction – for theoretical generalization, clarification of the conceptual apparatus on the problem, formulation of conclusions; method of expert assessments – in determining the factors of climate risks of an agricultural enterprise and conducting an assessment of the effectiveness of the risk management system; experimental game techniques, in particular the method of game theory, – to determine alternatives when choosing the behavior of the enterprise in different situations of uncertainty; linear programming method – for predicting climatic risk.

3 Results and Discussion

Climate change poses an increased risk for people, capital (economy), and the environment; Risk assessment from climate change is one of the most important bases for any adaptation strategy, because it can help program developers to select and implement the best solutions. While risk assessment is not a new concept and is constantly being used in various socio-economic sectors, the assessment of the risks from climate change is still something unusual. In particular, the assessment of the risks of climate change aims to «identify the threats that may or may become more severe from climate change, and assess their likelihood and their consequences in order to properly respond to these threats and reduce their risks». The risks associated with climate change are not static, but are likely to change over time, depending on changes in population size, land use and economic growth or decline.

Risk assessment can be qualitative and quantitative. Quantitative assessments focus on the calculation of the probability of certain effects and possible losses from them, where the risk = probability of danger x potential losses. This formula reflects a more detailed description of risks and uncertainties. In general, quantitative estimates take a lot of time, as well as large volumes of data with a high degree of technical expertise. While a quantitative risk assessment can become a powerful tool for adaptation decisions, it cannot be performed without a broad, qualitative assessment.

Since 1989, Ukraine has been experiencing an almost continuous period of warming – the average annual air temperature increased by almost 0.9 ° C, in 75% of cases it was 0.8-1.5 ° C higher than normal [1]. That led to changes in the rhythm of seasonal phenomena – spring floods and snowfall at the beginning of flowering; Also, extreme weather phenomena became more frequent, which in general impacted on the economic results of the economic activity of agricultural producers (floods on the Danube in 2005, the Dniester and the Transcarpathia in August 2008, droughts throughout Ukraine in 2007, record snowfalls in the west and in the central part of the country in March 2013 and in December 2009 in the south) [2].

The arid years have become more frequent as compared to the first half of the twentieth century, indicating a significant change in the climate. In arid years, the yield of grain, not only late and early spring, but also winter grain crops, is reduced too much. In this region, the probability of their onset is already high. In particular, different intensity of drought in the steppe zone of Ukraine was observed in 1907, 1916, 1920, 1921, 1923, 1934, 1940, 1948, 1951, 1954, 1957, 1968, 1975, 1981, 1983, 1986, 1992, 1994, 1997, 2007 years Drought was very strong in 1922, 1946, 1954, 1994, 2003, 2007 and 2009. Statistics show that in 110 years there were recorded more than 70 droughts, too strong – in 1891, 1901, 1911, 1921, 1922, 1938, 1939, 1946, 1957, 1959, 1963, 1965, 1968, 1972, 1975, 1979, 1983, 1992, 1996, 1999, 2003, 2007. Drought was severe in 1891, 1921 and 1976. Between 1956 and 2005, there were 60 droughts that covered more than 10% of the area and had a significant intensityю During the years of independence in Ukraine there were 10 droughts: 1992, 1994, 1996, 1999, 2000, 2002 (in the Crimea), 2003, 2005 (second half of the year), 2007, 2009. In their observations, M. Barabash and T. Korzh noted that 1999, 2001, 2007, 2009 were the warmest in 100 years. In those years, 11 of the 12 months were abnormally warm [3].

In the first decade of the twenty-first century. The drought of 2007, which covered a considerable area of the steppe zone of Ukraine, was very strong. In this huge area in April-May and early June there was no precipitation for 40-50 days. The negative impact of drought has intensified by a very dry autumn and abnormally warm and almost snowless winter. Therefore, it is believed that in this zone of drought – not an accident, but ordinary, often repeated, natural phenomenon. As it is known, the inhibition of crops begins in the absence of rains for more than 25 days on all types of soil, it increases in the absence of them for 30-40 days, and in the long run, cereal crops, perennial and perennial grasses and other cultures with a short vegetative period suffer from drought .

Based on available information, has developed criteria for assessing drought. These criteria eliminate the shortcomings of criteria developed earlier, in which there are no measurable indicators and characteristics of drought (Table 1).

Table 1 **Extended criteria for determining drought**

Elements of drought evaluation	Intensity of drought	Indexes
The duration of the dry period (in the absence of effective rainfall of more than 5 mm per day) – the number of days	Weak	20-25 days
	average	25-30 days
	strong	30-35 days
	too strong	more than 35 days
Rainfall per month in% to multi-year level	Weak	81-90%
	average	61-80%
	strong	41-60%
	too strong	40% or less
The presence of productive moisture in the soil in a layer 0-20 cm	Weak	16-20 mm
	average	11-15 mm
	strong	5-10 mm
	too strong	less than 5 mm (for 3 decades)
The presence of productive moisture in the soil in a layer 0-20 cm	Weak	91-100 mm
	average	71-90 mm
	strong	51-70 mm
	too strong	less than 51 mm
Relative humidity of air is less than 30%, with air temperature +25 ° C and above and wind speed more than 5 m / s (dry), the number of days per month	Weak	3-4 days
	average	5-9 days
	strong	10-14 days
	too strong	more than 14 days
Hydrothermal coefficient for the estimated period	Weak	0.6-0.8
	average	0.4-0.6
	strong	0.25-0.4
	too strong	less than 0.25

Source: Barabash, MB, Korzh, T.V., Tatarchuk, O.G. (2004). Research of changes and precipitation fluctuations at the turn of the XX and XXI centuries. in conditions of global warming the climate

The refined criteria make it possible to evaluate the drought comprehensively and comprehensively, their use for a long period provides a reliable assessment of the intensity of drought and its consequences for most crops, as well as for the calculation of expected losses. The necessity of determining the independent weather indicators of drought for the development of parametric insurance schemes in Ukraine is substantiated. The development of parametric insurance schemes for crops against drought risk, in particular in its northern grain-growing regions, requires the initial identification of independent weather indicators for the manifestation of this risk. In parametric insurance schemes, independent weather indicators act as indices that determine the fact of the occurrence of an insured event.

According to the scientific forecasts, an increase in the average annual temperature of 1 ° C causes a 10% reduction in agricultural output, and the projected increase in the average annual temperature of 1-3 ° C in the near future will have a major impact on cereal production [4]. Meanwhile, agriculture, in turn, contributes its own share in the global warming of greenhouse gases from industrial activities in this area.

According to the Ukrainian Weather Center, compared with 1961, the duration of the winter period has decreased for almost a month. Only some winters, for example 1985, 1987, 1997, were extremely cold and snowless, then winter crops faded in large areas. In the winter of 2002-2003, due to the prolonged occurrence of a powerful ice crust, about 70% of crops were killed [5].

Since 2000 there has been a tendency to increase the temperature in the summer, which is threatened by an increase in arid phenomena [6].

Changes in the temperature indices of the cold period and in the temperature regimes in the spring, starts the begin of the sowing campaign in recent years for 2 weeks earlier. There is a slight decrease for precipitation throughout Ukraine, which adversely affects the formation of sufficient soil moisture and promotes the spread of droughts to the northern regions of Ukraine. In the last decades, the actual displacement of the boundaries of natural-climatic zones is 100-150 km to the north [7]. Changing natural and climatic conditions leads to a change in the structure of the crops area of the main crops (Table 2).

Table 2 **Structure of crop area in agricultural enterprises of Ukraine (%)**

Zone	The name of cultures	1961-1970	1971-1980	1981-1990	1991-2000	2001-2014
Steppe	including crops	50,13	47,58	51,03	46,81	57,29
	winter wheat	21,69	25,97	20,36	10,67	24,82
	sugar beet	1,42	1,29	1,25	1,74	0,06
	sunflower	10,74	11,12	9,25	11,30	28,77
	others	37,72	40,01	38,47	40,16	13,88
	Total	100	100	100	100	100
Forest-steppe	including crops	51,30	49,80	50,86	45,32	54,76
	winter wheat	27,09	22,33	20,10	18,26	24,04
	sugar beet	12,83	12,23	11,60	11,76	3,18
	sunflower	2,09	2,15	1,73	3,08	7,00
	others	33,77	35,82	35,80	39,84	35,07
	Total	100	100	100	100	100
Polissya	including crops	48,01	43,58	42,49	44,47	52,35
	winter wheat	16,48	12,82	17,26	19,11	28,17
	sugar beet	7,44	6,64	5,02	4,72	1,78
	sunflower	0,00	0,00	0,00	0,00	0,06
	others	44,56	49,78	52,48	50,81	45,81
	Total	100	100	100	100	100

Source: Adamenko T.I. (November 22, 2013). Climate change and its impact on agro-climatic resources of Ukraine. Presentation at the round table «Development of agrarian production in conditions of natural and climatic changes»

The main feature that characterizes the change in the structure of sown areas, caused by natural and climatic conditions, is the growth of sunflower crops in the farms of the forest-steppe and Polissya.

Reducing the amount of precipitation and increasing the average daily temperature creates unfavourable conditions for growing sugar beets. Thus, over the past 50 years, the share of their crops in the enterprises of the corporate sector in the Steppe zone has decreased by 1.32 pp. Similar phenomenon was observed in the forest-steppe zone [8].

Our research has found that the result of the influence of natural and climatic conditions on the cultivation of agricultural crops became significant fluctuations in their yields.

According to the results of the conducted studies, significant decline in winter wheat yields was observed until 2000 1-2 times per decade. In the first decade there were three significant crop yields.

The most significant indicator characterizing the impact of climatic conditions on cultivation is the variation of the mean linear deviation. Based on the data in Figure 1, the calculation of the levels of the above-mentioned indicators (Table 3) was carried out, which shows an increase in the value of the indicator of the magnitude of the variation of the dynamic rows of wheat yield on average more than twice.

Table 3 **The magnitude of variation and variation of mean wheat yield in agricultural enterprises**

Zone	Value	1961-1970	1971-1980	1981-1990	1991-2000	2001-2014
Ukraine	Swing variation	8,9	8,8	14,6	16,9	24
	Midline value	0,07	0,3	0,1	-0,7	-0,01
Steppe	Swing variation	14,4	17,3	21,6	22,3	27,2
	Midline value	0,03	0,6	0,1	-0,8	-0,02
Forest-steppe	Swing variation	15,5	17,6	18,3	21,3	29,7
	Midline value	0,06	0,6	0,1	-0,9	0,01
Polissya	Swing variation	9,7	10,7	11	13	12,6
	Midline value	0,03	0,2	0,1	-0,4	0,08

Source: Author's development.

Changing yields in time depends on many factors, which are divided into three groups: soil, weather and technology of production of crop. By the nature of manifestation, all factors are divided into two groups: deterministic and random [9]. Deterministic is the degradation of soil, technology improvement and climate change. Incidental factors include, for example, the average weather conditions during the growing season, events that are stressful to plants (short-term droughts and frost, plant diseases and pests, grassland vegetation), as well as the uncertainty of counting yields that are of a random nature.

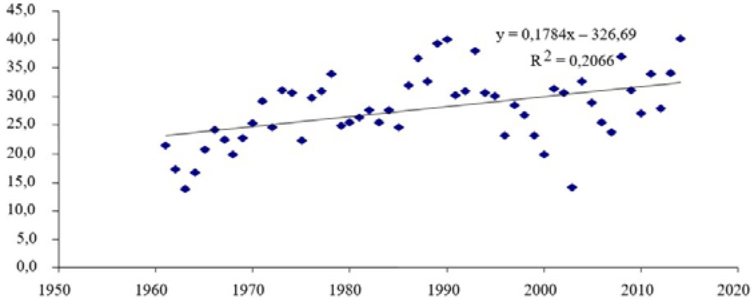
Since yields depend on random factors, yields are a random process for describing which uses two concepts of a single event (yielding one year) and the implementation of a random process (a series of individual events that were registered at a certain interval time). So, data on yield over a number of years is the realization of a random process. It is very important that it is unknown what kind of realization will be in the future.

Since the full yield characteristic (as a random variable) is its probability distribution function, the solution of the problem of estimating the effect on the yield of deterministic and random factors is reduced to finding this function.

The yield increase, that is, the trend, is described by the linear regression equation: y = 0.1784x – 326.69, where x is the time, year; y – yield, q ha -1.

Determination coefficient R2 = 0.2068. In Figure 1 a straight line represents this equation.

Figure 1 **Dynamics of wheat yield in Ukraine**



Source: Author's development.

Trend is treated as the influence of deterministic factors. In this case, it is the progress of technology, which is associated, for example, with the increase of fertilizer doses, with the use of plant protection products and using more productive varieties, which leads to higher yields. The degradation of the soil, which aggravated its agronomic properties and quality, on the contrary, leads to a decrease in yield. As yields grew, the effect of technological progress was more on the effect of soil degradation. This means that the technological cost of growing crops can be divided into two parts. The first part offset the decline in yield due to degradation (the more soil degraded, the more costs were needed to compensate for the effects of degradation). The second part provided for an increase in yields (these costs also increased).

A deviation from the trend is interpreted as the effect of random factors. Y yield was represented by the dependence Y (x) = Y $_{trend}$ (x) E, where E is the relative yield (relative to the trend), taking into account random factors. For each year, the values E *i* = Y i / Y $_{trend}$ ($_t$*i*), *i* = 1, 2, ..., 55 – serial number of the year were calculated. Here Y *i* is the actual yield in the x-th year, and the Y $_{trend}$ ($_t$*i*) is calculated on the trend equation of yield in the same year. The application of a number of values {$_E$*i*} of the Kolmogorov-Smirnov and Student criteria has led to the conclusion that at the 5% level of significance, the hypothesis about the truncated normal distribution of the random variable E with the mean value of E $_{environments}$ = 1. The values of the standard deviation and the coefficient of variation levels, respectively, y E = 0.13, e E = 13%. According to the theory of probability it follows:

1) the absolute yield Y is also described by the truncated normal distribution; its average value of Y $_{environment}$ (t) = Y $_{trend}$ (t), that is, the trend describes the dynamics of average yield;

2) standard deviation for absolute yield $_y$ *Y (t)* = *Y* $_{trend}$ *(t)* $_y$*E*; 3) for the absolute and relative yield, the coefficient of variation is the same, that is, $_e$ *Y* = $_e$*E*.

In Figure 1 coefficient of variation characterizes the distribution of points in relation to the trend line: the smaller the value of the coefficient, the smaller the spread, that is, the less impact of random factors. Consequently, the coefficient of variation can be used as an estimate of yield stability in relation to the influence of random factors. The smaller it is, the higher is the yield stability. Since the normal distribution is determined only by the mean value and the standard deviation, this means that the desired probability distribution function for the yield has been found, and at the same time it was possible to separate the effect on the yield of deterministic and random factors.

In Figure 1 linear trend of productivity growth can not last indefinitely. The time will come when losses from soil degradation will be higher than productivity gains at the expense of technology. Then the productivity growth will slow down and may come a moment when the trend will reach the maximum, after which the yield will begin to decline. In the future, with the decrease of humus stock, the average yield will decrease. This confirms the real danger that the trend shown in Figure 1, can reach the maximum, after which the yield will decrease.

It should be noted that the minimization of the negative influence of weather risks in accordance with the processed results of the survey of agricultural producers is mainly carried out through insurance of crops (30%) and insurance of expenses (6%). However, the vast majority of respondents (64%) do not take any action on weather risk management at all, either because of lack of funds or lack of need.

In our opinion, to minimize the risks of farming, especially in unstable climatic zones, are needed new methods and approaches to manage the state of land resources, in particular soil fertility, optimization of productivity of cultivated crops with concrete proposals, how, where and when to grow and by which technologies [10].

Based on data on the vulnerability of agricultural crops to climate change, diseases and pests, we should target selection work for the withdrawal of crops resistant to changes in weather conditions and diseases. Particular importance in resolving issues of adaptation of plant growing to climate change becomes selective for ecological plasticity, which makes it possible to obtain stable and high yields under different vegetation conditions and adapt different types of plants under cultivation in adverse climatic conditions, making them more resistant to various weather events and harmful insects. For example, China, as the world leader in the production of wheat (the share of the country in world production is about 20%), its achievements in this are obliged to breeding varieties. The withdrawal and improvement of new varieties of wheat allows Chinese farmers to achieve a yield increase of an average of 1.5% per year.

As a direction of domestic agrarian enterprises adaptation to global climate change can become use: without-field cultivation of soil, which holds moisture in the soil, improves the availability of water, reduces soil erosion, increases water content; the introduction of agricultural production of alternative agricultural models borrowed from foreign experience in particular, Mini-Farming (Biointensive Mini-Farming), Biodynamic Agriculture, Effective Microorganism Technologies, LISA – Low Input Sustainable Agriculture), based on a deep understanding of the processes occurring in nature, aimed at improving the structure of soils, reproducing their natural fertility and contributing to the formation of environmentally sustainable agro-landscapes [11].

The offset is in the time of sowing, and accordingly, of all other stages, depending on the weather conditions. Some farms, using the fact that the harvest ends earlier, until the winter crops have time to carry out additional operations to feed and control the weeds, including hanging side rates.

Use of seeds resistant to drought and high temperatures of varieties or hybrids. There is a widespread practice of annual purchases of corn and sunflower seeds from international companies, while wheat and other crops are often of Ukrainian origin. One way or another, but one can say with certainty that when choosing seed material Ukrainian agrarians consider its resistance to climatic factors.

Due to adverse weather conditions (strong winds, temperatures), some farms carry out work at night, when their execution can be more convenient or more efficient [12].

I must say that Ukraine has a strong scientific and practical base for the development of adaptation strategies for climate change, taking into account the specific features of our region. In particular, such work is being carried out, there is a significant interest in its development in the Ukrainian Research Institute of Prognostication and Testing Technology, and Technologies for Agricultural Production named after Leonid Pohorilly.

Thus, global warming in Ukraine in the coming years will have both a positive and a negative impact on agriculture. This effect will be different in different agro-climatic zones – increasing the length of the growing season in the northern part of the country will be positive for agriculture, in the southern part of the country, on the contrary, it will lead to an increase in droughts. The consequences of climate change are inevitable not only for the main agricultural crops, but also for horticulture, viticulture in Ukraine [13].

About two approaches to insurance – the weather index and the index of productivity.

The first one – not popular, but cheap, requires one-time significant costs and insignificant current.

The second one is being implemented, but it always needs material and human costs.

In our opinion, it is necessary to convince insurers of the possibility of an objective and sufficiently accurate assessment of possible losses using various hydrometeorological information and expert assessments. Moreover, over time, these opportunities will be improved.

The basis of the proposed insurance product is the level of intensity of manifestation of this insurance risk in accordance with the methodology proposed above. Lack of yield is compensated if the yield is below a certain level (trigger), which is set for all regions in accordance with the technology of grain production.

The task of an expert is to determine the expected (biological) yield. If the yield falls below the level specified in the contract, the insurance company pays the indemnity. In addition, the compensation is paid automatically, that is, without conducting a field survey, if the deficiency of precipitation during the growing cycle is less than 55% of the norm. To calculate the rainfall rate, is used data for 30 years.

Inspection and analysis of crops are necessary to determine the loss of crop due to drought, as well as to determine the decline in yield under the influence of other factors. The main parameters are fixed: rainfall: 10% of the deficit; plant density; the presence of pests and diseases; non-compliance with the requirements of culture production technology.

The determination of yields is carried out in four stages, starting with the phase of waxy maturity (XI stage of organogenesis by F. M. Kuperman): the selection of random ears on a plot of 1 sq.m; weighing of ears from the point of sampling (weight of ears from 1 sq. m); determination of grain moisture content,%; determination of yield, kg / ha.

The main condition of the contract is the level of franchise. It is proposed, that for a very severe drought, according to the proposed classification, its level is 0, strong – 75%, average – 50%, weak – 25%. This value is intended for agricultural enterprises of the steppe zone. For the forest-steppe and Polissya zones, it will be adjusted to the magnitude of the drought index calculated by A.V. Meshchersky and V.G. Blazhevich on the territory of the distribution of this natural phenomenon.

The cost basis for determining the insurance indemnity will be the level of procurement prices for the main channels of marketing for certain types of grain crops at the time of conclusion of the contract. As the analysis of a possible manifestation of drought with the degree "too strong", the size of losses in this case are beyond the capabilities of the commercial insurance market. Therefore, this risk is not covered by insurance programs. In this case, a multi-disciplinary program should be in place, which will be part of the state subsidy for the production of agricultural products in areas of increased risk-taking in agriculture.

The use of this insurance product would compensate the losses incurred by agricultural enterprises for UAH 3600 million, which in a natural equivalent is equal to 4 million tons of grain crops. The state reimbursed UAH 400-500 million.

4 Conclusions

It is determined that global warming in Ukraine in the coming years will have both a positive and a negative impact on agriculture. This effect will be different in different agro-climatic zones – increasing the length of the growing season in the northern part of the country will be positive for agriculture, in the southern part of the country, on the contrary, it will lead to an increase in droughts.

The consequences of climate change are inevitable not only for the main crops, but also for horticulture, viticulture in Ukraine. Due to the fact that the climatic risks have become more and more often the task of developing effective insurance products based on the weather and productivity index.

To effectively use the received heat resources, to reduce the risks of further temperature increase, it is necessary to develop and implement a system of adaptation measures, namely: introduction of water-saving irrigation technologies, creation of new drought tolerant varieties and hybrids, formation of stable agro-ecosystems, capable of functioning under more severe climatic conditions. In addition, the necessary ecological optimization of the structure of landscapes and land use systems based on the reduction of agricultural land cultivation, minimization of degradation processes and reproduction of soil fertility by achieving a deficit-free balance of humus and biogenic elements in agro ecosystems, the development of effective systems for protecting plants from pests and diseases.

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