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CLIMATE CHANGES IN UKRAINE: AGRARIAN ASPECT

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Abstract. *The article identifies and substantiates the challenges and prospects of agriculture under the climate change. Ukrainian agriculture serves as an important component of global food security, whose further development is dependent on natural resources, the environment and climate change. Agriculture is a significant source of greenhouse gas emissions, however, at the same time, it is suffering from the climate change itself. Although Ukraine is not included in the list of the most vulnerable to global warming regions on our planet, if no appropriate urgent action is taken, the climate change will continue to pressure on the agricultural ecosystems.*

The authors highlight positive (changed terms and conditions of harvesting, increased efficiency of fertilizers, etc.) and negative (deterioration of grain quality, increased frequency of droughts, etc.) effects of the climate change on agriculture; they identify and summarize the main measures to reduce the negative impact of agriculture on climate change and propose various basic adaptation measures that would mitigate the negative impact of the climate change on agriculture.

Under the conditions of climate change, an important factor in improving the efficiency of agriculture is a rigorous distribution of arable lands between separate crops with regard to climate change. One of the important measures to improve the crop rotation pattern is including so called "niche" crops that have a significant potential for the diversification of the oilseed-and-grain pattern, which dominates in the crop rotations in southern Ukraine.

Keywords: *climate change, greenhouse gases, precipitation, temperature, agricultural sector, low-carbon agriculture, niche cultures.*

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Introduction. The current development of the agrarian sector is based on the concept of sustainable development which covers the economic, environmental and social challenges that society face today. It changes traditional views on agriculture. As the world population is growing, agriculture strengthens its position as the main supplier of resources to provide humanity with food and income in order to improve their living standards. At the same time, agriculture is a significant source of greenhouse gas emission which is a major cause of global climate change. Thus, if the volumes of agrarian production keep increasing, its negative impact on the environment is upscaling. On the other hand, climate change increases the risks of agricultural production. Consequently, the society faces the need to modernize the traditional model of agrarian production, taking into account the global climate change.

Analysis of recent researches and publications. Several authors believe that climate change is a major issue related to global food security. Its effective provision is possible under condition of improvements made to the management of agricultural systems and available natural resources. The future of food security directly depends on natural resources, the state of the environment and climate change [1, p. 12; 2, p. 15; 3, p. 108].

The aim of the articles. The objective of research is to analyse the main aspects of climate change impact on agriculture in Ukraine, to justify measures to minimize its impact on agricultural production and reduce the impact of agriculture on the environment.

Research results. Ensuring food security is possible by creating appropriate conditions to adapt agricultural producers to modern changes. Transformation in the agrarian sector should be done in order to feed the growing population of the planet (according to the World Bank forecasts, by 2050 the population

will increase to nine billion, and food production worldwide - by 70-100%), to reduce poverty and to ensure the economic growth without harming the natural resource potential.

The World climate change is happening faster than scientists predicted. At the end of 2015, at the 21st Conference of Parties of the UN Framework Convention on Climate Change, the Paris Climate Agreement [4] was adopted and was signed on behalf of Ukraine in April 2016 in New York [5]. This agreement replaces the Kyoto Protocol to the UN Framework Convention on Climate Change. Assembly of the Paris Summit aimed to study strategies to stabilize greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference into the climate system. Scientific research results show that 2ºC temperature increase on Earth, compared to pre-industrial times, will have dangerous and unpredictable effect on climate (faster melting of glaciers will lead to flooding the coastal towns and small islands, the extinction of many species of animals and other destructive weather events). Since 1850, the average temperature has increased by 1ºC, though the agreed safe limit for global warming is 2ºC. Moreover, the level of CO_2 has grown up by 30% after the Industrial Revolution, since 1979 the ice melt in the Arctic Ocean has increased (by 4% in 10 years), the new century will have 9 of 10 hottest years [6].

Therefore, the aim of the Paris Summit was to develop ways to constrain carbon emissions, enabling countries to continue economic development and provide support to the least developed areas and those most affected by rising temperatures.

Within the framework of the Paris Agreement the global goal of preventing temperature increase of more than 2ºC in comparison to pre-industrial level has been set, aiming to reduce this temperature to 1,5ºC [6].

The main reason for the Agreement ratification in our country is the fact that the issue of greenhouse gas emission reductions for Ukraine is connected to decreasing of the share of fossil fuels, ensuring energy independence, differentiation of energy supply and sustainable development of the country.

However, the fight against climate change requires significant financial resources. Experts estimate that global climate change requires 114 trillion USD, and Ukraine needs more than 100 billion USD. In the autumn of 2017, an attempt was made to find sources of funding at the climate conference of the signatories of the United Nations Framework Convention on Climate Change (COP 23) in Bonn. These issues were discussed, in particular, in the Bonn Zone, which directly concerned the real economy, the public and the financial market. Participants exchanged advances in technologies and financial instruments to reduce emissions, accumulate financial resources [7].

According to the World Economic Forum, the delay of global warming within 2ºC by 2030 costs 114 trillion USD. But according to the Climate Policy Initiative, the world spends over 500 billion USD each year on climate change, that is, the gap between needs and capabilities. It was indicated that the main problem is the lack of a regulatory framework for the functioning of this market segment. The climate deal should be approved by the NDCs (Nationally Determined Contributions) and the mechanism for exchanging certified greenhouse gas (GHG) emission reduction units [7].

Large companies already understand that ignoring climate risks (floods, droughts, etc.) can lead to future losses and they are preparing for a potential increase in the price of greenhouse gas emissions in the future. That is why, due to the lack of a single standard for green projects, they actively use debt-climatic finance and prepare to increase the price of greenhouse gas emissions in the next 3-5 years, for which they actively reduce greenhouse gas emissions, increase energy efficiency and production of electricity from renewable sources. In addition to this, the market for greenhouse gas emissions trading should operate, with fluctuations in prices for allowances, taking into account supply and demand. As a result, countries where emission reductions will be relatively expensive will be able to buy them where emission reductions can be achieved at lower cost.

Ukraine committed to reduce greenhouse gas emissions and build a "green" economy. That is to rebuild its economy, make it energy efficient, switch from using traditional energy resources (coal, gas) to renewable energy sources. It will cost more than 100 billion USD, which is comparable to the country's external public debt. According to the conclusions of the "Zone Bonn" COP23 panel to solve the above mentioned problems both the world and Ukraine should move in the following direction:

- introduction of public-private mechanism of accumulation and distribution of climatic finance as the most effective for solving these problems;
- ensuring the growth of the climate finance market, which requires a universal mechanism for the accumulation of money;
- harmonisation and unification by each country of its own regulatory framework in the field of green finance;
- introduction of common standards for the definition of "green assets" at the international level, which will allow companies to invest in projects or other companies around the world on unified basis [7].

The impact of climate change on agriculture

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (hereafter referred to as the Report) covered current climate change and its causes, expected climate change, risks and impacts, future approaches to adaptation, mitigation and sustainable development at the global level. In this report, it is much more explicit in comparison to the past indicated the uniqueness of the warming and the widespread climate change.

The main conclusion of the report is a proof and evidence of human impact on climate change. Anthropogenic emissions of greenhouse gases caused by economic development and population growth have led to unprecedented levels of atmospheric concentrations of the main greenhouse gases - carbon dioxide, methane and nitrous oxide - in the last 800 years. Consequently, the world needs substantial and sustainable decarbonisation, which, along with adaptation measures, will limit the risks of climate change.

The report provides evidence that climate change is already taking place. Each of the last three decades was warmer than the previous one and warmer than any other starting from the beginning of the observation. By the end of the century the temperature will probably rise for 3,7 to 4,8°C or above.

The report provides pessimistic predictive assessment of food security in the context of climate change. Observations prove its negative impact on crop yields. In particular, in regions with tropical and temperate climate, a temperature increase of 2°C without adaptation to it will negatively affect the yield of wheat, maize, soya, and rice, although it will have positive effects in some regions. A global temperature increase of 4°C with the reduction of renewable sources of water and increased competition for water resources will trigger food security risks globally.

To predict changes in the climate system under assessment report on climate change a set of four scenarios was defined, it's called the Representative Concentration Pathways (RCP). They determine the approximate total amount of radiation exposure[1] in 2100 compared to 1750.

The four RCP scenarios include:

- emission reduction scenario, which is expected to have low climate impact (RCP 2.6);
- stability scenarios (RCP 4.5 and RCP 6.0);
- high GHG scenario (RCP 8.5) [4, p. 29].

The change in global temperature at the end of this century is likely to exceed 1,5°C compared to the period 1850-1900 in all scenarios of RCP, except for RCP 2.6, 2°C in RCP 6.0 and RCP 8.5 scenarios and may exceed 2°C in RCP 4.5 scenarios. Warming will continue after 2100 according to all scenarios of RCP, except for RCP 2.6 [8, p. 19-23].

According to the research conducted on the basis of the scenarios covered in the Report, in the period from 2010 to 2070 the temperature is expected to rise throughout Ukraine: about 1,65°C (Steppe) and 1,74°C (Forest-steppe) for the RCP 4.5 scenario and between 2,68°C (Mixed forests) and 2,98°C (Steppe) for RCP 8.5 scenario [9, p. 21].

[1] Factors influencing climate change are natural and anthropogenic substances and processes that change the energy balance of the Earth. Radiation influence is a quantitative indicator of changes in energy flows caused by the change of these factors by 2011 compared to 1750. The positive value of radiation exposure leads to an increase of surface temperature, and the negative one leads to its decrease.

According to forecasts, climate change will not significantly affect the average rainfall. In the scenario RCP 4.5, the change in rainfall will range from 13 mm in the Steppe zone to 55 mm in the Forest-steppe. Tangible changes will take place in the scenario RCP 8.5 - more than 80 mm in the zone of Mixed forests and less than 13 mm in the zone of Steppe [9, p. 22]. And it is the Steppe area that may have a significant reduction in production by 2070 due to climate change. According to some estimates, wheat output will probably be reduced by 11% for the RCP 4.5 scenario and by 18% for the RCP 8.5 scenario [9, p. 26].

In addition, within the framework of the University of Notre Dame project, an assessment of the Global Adaptation Index (ND-GAIN) [10] is being made, which forms the world ranking of vulnerability to climate change, given countries' readiness to improve their resilience to climate change.

According to the University of Notre Dame, in the world ranking Ukraine is the 62th among 180 countries and it has the index ND-GAIN of 57,6 (New Zealand has the highest – 81,9, and Eritrea has the lowest – 24,9). This index is calculated on the basis of the vulnerability index and the readiness index to improve stability. The vulnerability index for Ukraine in the last period is improving: in the last few years it has decreased from 0,339 to 0,328. It identifies overall vulnerability by assessing the following components: food, water resources, health, ecosystem services, human habitat, as well as infrastructure. The worst scores in Ukraine were the following: the intensity of agriculture, the water level, the capacity of the dams. The readiness to improve the sustainability index (taking into account three components - economic readiness, readiness of management and social readiness) in the last period deteriorated from 0,511 to 0,480, primarily due to the indicator characterizing political stability and the level of non-violence, as well as the level of innovation development.

Thus, according to all estimates, Ukraine is not among the most vulnerable to the global warming regions on our planet, although the effects of climate change are becoming increasingly tangible for its territory. According to the data of the Ukrainian Hydrometeorological Center for the last 20 years, the average annual temperature in the summer has increased by 0,8°C in comparison to the climatic norm (1961-1990), and the average winter temperature has risen by almost 2°C. Mountain regions are characterised by slightly lower average annual air temperature growth: 0,7°C in the Ukrainian Carpathians and 0,3°C - in the Crimean Mountains. Such temperature changes influenced the rhythm of seasonal phenomena, the frequency and force of extreme weather conditions (abnormal heat in 2006, 2008, 2010, 2012, 2014, 2015, record snowfalls in the west and central part of the country in March 2013, etc.).

In the last years of this century, in each period there were local droughts in the south and south-east, in the central and eastern part of the Forest-steppe zone and throughout the Steppe zone. The severe droughts that took place in 2007 and 2009 were accompanied by a sharp deficiency of rainfall and covered significant territory of Ukraine (especially in May-June 2007 and July-August 2009) [11; 12, p. 3-5].

Now there is no extreme climatic situation in Ukraine's agriculture. However, rising air temperature and uneven distribution of rainfall which has a storm, local character in the warm period and do not provide an effective accumulation of moisture in the soil, led to an increase in the number and intensity of arid phenomena. In combination with other anthropogenic factors, this may lead to an expansion of the risk-taking zone and even to the desertification of some areas of the southern regions of Ukraine. The repetition of droughts in different agro-climatic zones is 20-40%. Over the past 20 years, the recurrence of droughts has almost doubled. There is a dangerous tendency to increase the repetition of arid conditions in the zone of sufficient atmospheric humidification, covering Polissya and northern areas of the Forest-steppe [13, p. 9-12; 14].

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. With the current warming and unchanged rainfall, part of the territory of Ukraine may become unfit for agriculture in 10-15 years (part of Zaporizhzhya, Kherson, Mykolayiv and Odesa oblasts) [15].

In the next decade, climate change will have both positive and negative consequences for agriculture, which will differ, first of all, in agro-climatic zones. Extending the growing season will be favorable for farmers of Polissya area and in southern regions may lead to increased drought.

The results of research carried out at the Ukrainian Hydrometeorological Center in relation to the cultivation of the main grain crops (winter wheat and corn) using climate scenarios allowed to quantify the reaction of crops to the change of agro-climatic conditions of cultivation.

In particular, the next 10-20 years will be favorable for the production of winter wheat due to the possible shift of sowing terms for 20-40 days and more efficient use of the conditions of autumn vegetation, which can lead to an increase in total productivity of crops by 20-40%. According to these scenarios, in a 25-year period in the northern regions producers will sow sunflower and corn on the grain of more productive middle and late varieties. For early spring crops (spring barley, spring wheat, oats) raising the temperature background will cause a drop in their yields due to a decrease in the growing season and earlier maturation.

Climate change will also have a significant impact on the cultivation of vegetables - the border of the Steppe will significantly advance to the north, being in the current Forest-steppe zone. As a result, the northern limit of production of eggplants, sweet peppers and tomatoes will shift to the north, where these crops will be provided with heat. At the same time, there is a risk of reducing areas favorable for growing potatoes, cabbage and cucumbers [16]. One of the ways to adapt vegetable crops to the growth of temperature is pre-sowing hardening against drought, grain cultivation and seeds with salt. For example, potatoes become more durable to drought, when before landing to warm it to 35-38°C [17].

Climate change in Ukraine in the direction of warming will also contribute to the formation of favourable conditions for the intensive development of dairy cattle breeding and breeding of pigs in the western Polissya and right-bank forest steppe, meat cattle breeding in the Steppe and western regions of the Polissya [18, p. 203].

Vulnerability assessment of population and climate change adaptation should be a key component of agricultural policy. Such adaptation measures as preserving water resources in the soil (i.e., no-till), the introduction of drought tolerant varieties of agricultural crops and the development of irrigation are crucial for increasing resistance to climate change and food security, especially in the South [19, p. 9].

For agriculture, warming will have both positive and negative effects. The following should be considered as positive: improving conditions and reducing the harvest time; the possibility of effective introduction of late varieties (hybrids) using increased temperature resources; improving conditions of winter crops and perennial grasses; increasing fertilizer efficiency. The negative consequences include: increasing the amount of carbon dioxide will have positive effect on the yield of crops but it will cause grain quality deterioration; increasing repeatability and severity of droughts during the growing season; accelerating the decomposition of humus in soils; soil moisture deterioration in the southern regions; lack of full vernalisation of grain; increasing the number of pests, the spread of pathogens of plant diseases and weeds due to favourable conditions for their wintering; increasing wind and water erosion of the soil caused by an increase in the number of droughts and extreme rainfall; increasing risk of winter crops freezing due to the lack of stable snow cover with a significant decrease in temperature.

Weather conditions of recent years have shown the necessity of crops adaptation to global warming conditions, as the cultivating crops profitability to a large extent depends on this.

The impact of agriculture on climate change

The problem of food security and its ecological component have been recognised as one of the top priorities of the 21st century. The question of increasing food production should be solved taking into account the natural-resource component, which will reduce the negative environmental impact. In the context of global climate change, agriculture, as a determining factor in ensuring food security, faces two interrelated challenges: the modernisation of existing production technologies to counteract the negative effects of climate on production; having modernised the technologies ensure the increase of production that minimize greenhouse gas emissions.

Agriculture is a significant source of greenhouse gas emissions. The intensification of the industry and the introduction of new technologies contribute to its growth. At the same time, the main greenhouse gases are methane (CH_4) and nitrous oxide (N_2O), having 21 and 310 times, respectively, greater potential

for global warming compared with CO_2 [20, p. 26]. The share of world agriculture is about 10-12% of the total volume of anthropogenic emissions of greenhouse gases, which is dominated by emissions of nitrogen oxides from soil and methane from intestinal fermentation.

The constant growth of crop production without introducing measures of rational land use leads to a reduction of carbon stocks in mineral soils and an increase in its emissions from land cultivation. Growth in livestock production also causes an increase in greenhouse gas emissions (Table 1). Thus, the development of low-carbon agriculture should become a priority in terms of increasing production volumes [21, p. 24-25].

Low-carbon development is a country strategy that combines climate change and national economic development priorities. In Ukraine, there was a need for a transition to a sustainable low-carbon development model, which would reduce the magnitude of the negative impact on the environment by reducing emissions and increase the competitiveness of products by reducing the dependence on carbon stock and its share in the cost of the final product [22, p. 23-28].

Livestock breeding is one of the most important factors in the formation of food security of the country, which provides the population with food, promotes optimal use of food waste and plant residues after harvest, and provides crop production with environmentally friendly organic fertilisers. However, it is the main source of greenhouse gas emissions - methane (CH_4) and nitric oxide-1 (N_2O) [23].

Table 1. Structure of pollutants emissions in terms of production and technological processes in agriculture and forestry,%

Indicators	2012	2013	2014	2015
Agriculture and forestry, land use and forest biomass change	**100,0**	**100,0**	**100,0**	**100,0**
Cultivation of agricultural crops using fertilisers (except manure)	0,3	0,3	0,3	0,6
Cultivation of agricultural crops without fertilisers	0,01	0,4	0,4	0,4
Enteral (intestinal) fermentation	65,4	55,4	53,6	54,0
Cleaning, storage and use of manure and organic compounds	32,2	41,2	43,2	42,5
Use of pesticides and limestone	0,0	0,0	0,0	0,1
Cleaning, storage and use of manure and nitrogen compounds	2,0	2,7	2,5	2,4

Source: Calculated by the authors according to the State Statistics Service of Ukraine data for several years.

Another reason for the increase in carbon emissions from agricultural land is the overall deterioration of the balance and the decrease of humus in soils and the rate of its mineralisation to meet the needs of plants in nutrients.

Humus is the most valuable organic and biologically active component of the soil. A century ago the Ukrainian soil contained an average of 4-6% of humus, but now it is 3,2%. It should be noted that when the soil contains less than 2,5% of humus – it is not black soil. According to the materials of agrochemical certification of agricultural land, which is carried by branches of the Institute of Soil Protection of Ukraine, it is defined that every 5 years our soils lose an average of 0,05% of humus. In monetary terms, during twenty years, this amounts to about 450 billion hryvnia (UAH). To maintain a proper balance of humus in the soil it is necessary to fertilise 1 hectare of cultivated area with about 8-10 tons of organic fertilizer annually. Each year, the soil loses about 400-500 kg of organic elements per hectare and unfortunately it is not possible to replenish this loss. 100 years needed to get 1% of humus [24, p. 12].

The restoration and preservation of humus and soil fertility contribute to reducing carbon emissions from land cultivation, which requires the application of scientifically based agrotechnologies, where the fertiliser is the main component. Unfortunately, in the last few decades, due to the reduction in livestock population, there is a decrease in the volumes of organic fertilizers (in 1990 – 257,1 million tons, 2000 – 28,4, in 2014 – 9,9 million tons) [25, p. 147]. The growth of volumes of crop production and the intensity

of exploitation of agricultural land leads not only to an increase in carbon emissions, but also to the loss of nutrients and minerals, which results in decreasing the fertility of soils.

In conditions of manure deficiency, using post-harvest corn crops accelerates the infiltration of moisture into the soil, weakens erosion, absorbs residual undersized nitrogen for harvesting and it is 2-3 times more efficient than manure[2]. Crushed post-harvest corn crops remaining in the surface layer of soil and on its surface take on (quench) the kinetic energy of rain drops, preventing soiling and formation of the surface crust, weaken erosion and absorb the residual undersized nitrogen, thereby preventing harvest loss and contamination of groundwater. Moreover while decaying it improves the harvest of the next cultivated culture [26, p. 9-10].

Sapropel is an alternative source of organic fertilisers, along with sowing fertilizers, post-harvest residues, various types of compost, etc. [27, p. 28-35]. Using 30 tons of sapropel fertilizer per hectare in Polissya and Forest-steppe contributes to the formation of an average of 1,3 tons per 1 ha of humus, in case of increasing fertiliser usage to 60 tons per 1 ha, the formation of humus increases to 2.6 t / ha. Due to this, not only the fertility and moisture-retaining capacity of the soil, but also the productivity of all groups of crops increases [28, p. 235-237].

Increasing the area under perennial grasses reduces carbon emissions by 17%. In addition to the use of new soil cultivation technologies, crop rotation as an effective measure to conserve carbon stock in the soil is an important component, which increases the yield of arable land by 25-30%. The above mentioned measures will promote low-carbon development of the agrarian sector.

The use of new breeding varieties in crop production is also positive for storing carbon stocks in a soil reservoir. Adapted to specific natural and climatic conditions, varieties of agricultural crops allow to obtain high yields at a lower level of mineralization of soils [28, p. 239].

In agriculture, the most cost-effective options for mitigating the impact of climate change are the rational use of arable land and pastures, as well as the restoration of organic soils.

Niche crops in the context of climate change

Within the conditions of climate change, scientifically grounded formation of agricultural crop area is an important factor in improving the efficiency of agriculture, taking into account climate change, adaptation of crop production to these changes, which will result in the most effective use of natural resources in the new climatic conditions.

One of important measures to improve the crop rotation structure is to include niche crops that have significant potential for diversification of the monocultural oilseed and grain trend, dominant in the crop rotation of the south of Ukraine. The main niche cultures are oats, rye, buckwheat, flax, mustard, camelina, peas, beans, sorghum, etc.

So far, there is no consensus among the experts on which crops to be considered as niche ones – some researches include crops that require further deep processing and are used in related industries such as pharmaceutical, confectionery, textile (flax, hemp, thistle, camelina, mustard). Others include crops and oilseeds, the volume of production of which is several times smaller than the main crops.

Niche cultures can be used as replacement for fallen grains or oilseeds. For example, buckwheat is one of the latest (by the time of sowing) spring crops, it is widely used as a replacement for dead winter crops. Flax is also suitable for this. To reduce losses caused by drought, some market participants replace traditional crops and oilseeds with a drought-tolerant sorghum.

However, these crops cannot become widespread, as they have a limited demand and will be highly marginal only if they maintain in their niche. However, they are an effective tool for regulating crop rotation, and in the face of lower world prices for major agricultural crops, especially maize and wheat, they may be of interest to producers [29].

Oats is considered as a niche culture; its cultivation does not require favourable climatic conditions, because it is unpretentious to temperatures and has the ability to adapt to different types of soils. Oats is

[2] 3-4 tons of straw is equivalent to 9 tons of manure per hectare.

used in the production of agro-food products and as feed for livestock, due to the content of a significant amount of nutrients.

Rye is one of the few crops that can be grown on scarce land, it is resistant to drought and frosts. Today, the seed market presents a large variety of high-yielding hybrids of rye, which are well adapted to sandy soils with low moisture content. Rye grain is a raw material for the baking industry, green mass is used for cattle fattening.

Buckwheat is a valuable cereal crop grown on black and degraded soils characterized by high aeration, moisture and waterproof. It is grown without chemical fertilizers and pesticides, because it is not afraid of weeds, as it can 'displace' them from the field. The culture is used both as post-harvest crops and as green manure for fertilization. Buckwheat is a good predecessor in crop rotation for other crops, especially when growing it in a wide variety of ways. Cultures grown in crop rotation after buckwheat are well fed with phosphorus and potassium due to its post-harvest residues. Buckwheat is a valuable honey culture because in favorable weather conditions, 1 hectare of it can provide 90-100 kg of high-quality medical honey [30].

In the south of Ukraine, mustard is an oilseed crop alternative to sunflower and rape, which can restore the optimal ratio of crops in crop rotation and provide a stable income to producers. Mustard improves phyto-sanitary state of the field, acts as an effective green manure and a good precursor for grain crops (as it suppresses growth of diseases). Seeds are used for the manufacture of mustard oil, powder for the production of sauces and medicines. Mustard seeds are almost entirely export-oriented products that are in demand in the European market, especially in Germany [31].

Oilseed flax is a crop, alternative to glabrata rape in crop rotation which may partly replace sunflower in the structure of consumption. It can be grown in different regions of Ukraine; it is income equivalent to other oilseeds. The advantages of oilseed flax are, firstly, its drought tolerance, and secondly, a short growing season that allows flax to be collected at the end of July, making it one of the best precursors for winter crops. Thirdly, resistance to adverse weather and climatic conditions, in particular, sprouting is resistant to spring frosts, and the culture itself - to the spillage of seeds and sinking. It is possible to seed up to 30% of sown area by flax, but the market of oilseed flax remains niche (0,2% of all crops) and has a small segment in the production of oilseeds (0,8% of crops of oilseeds) in Ukraine [31].

Camelina is a culture that belongs to the rape family and is grown as an accompanying crop with beans. Camelina oil is similar to linseed oil for high content of linoleic and linolenic fatty acids (Omega-3 and Omega-6). Camelina is rarely grown in Ukraine today, except for domestic needs. In 2015, only 71,2 hectares of this crop were sown in the country. Almost all of them were in the Sumy region.

Table 2. Dynamics of the collected area under niche crops, thousand hectares

Agricultural crops	1961*	1990	2000	2010	2014	2015
Rye	1723,1	517,2	638,1	279,1	185,1	150,8
Oats	706,4	485,9	481,0	310,8	243,6	210,5
Buckwheat	394,8	362,3	528,9	198,6	136,7	127,7
Oilseed flax	36,2	3,9	2,2	56,3	33,4	62,1
Mustard	2,2	1,6	19,6	106,4	96,3	58,8
Camelina	6,4	1,2	3,7	0,9	0,3	0,1
Peas	725,2	1270,8	285,2	278,5	153,5	168,7
Beans	8,8	23,5	33,2	22,6	28,7	35,5
Sorghum	12,2	24,9	14,4	28,7	83,1	50,6

**Sown area.*

Source: Calculated by the authors according to the State Statistics Service of Ukraine data for several years.

As noted above, cultures may lose their niche as a result of popularization at the same time reducing marginality and vice versa. During the last fifty years out of all crops listed in Table 2, rye and peas have become niche out of widespread crops, but other crops haven't lost their niche, having changed in 2-25 times in the area. Although their marginality, for example, buckwheat, is constantly changing due to market demand and the area under them changes accordingly.

Conclusion

1. According to the Intergovernmental Panel on Climate Change, Ukraine is not among the most vulnerable to the global warming regions of our planet. However, the changes that will be observed on its territory during current century will be substantial and will affect all areas of human life and the state of the environment. Unless appropriate immediate measures are taken, climate change will continue to exert pressure on agricultural ecosystems, and this will particularly affect the most vulnerable regions and populations.

2. One of the most serious problems of the impact of climate change on agricultural production will be the change in the length of the growing season of agricultural crops. An increase in its duration will be effective for the agriculture of the northern part of Ukraine, whereas in the southern regions, due to an increase in the average annual temperature of 1-2°C, arid phenomena can increase significantly. Taking into account the rising temperatures and virtually unchanged rainfall before 2030, the southern part of the country may become unfit for agriculture.

3. In order to minimize the impact of climate change on agricultural production, the focus should be on the following adaptation measures: development of agricultural systems with increased soil protection and moisture-saving qualities, the use of resource-saving technologies and mechanisms; the use of varieties of agricultural crops with a short vegetative period, resistant to diseases, pests and droughts, fluctuations in weather and zonal specialization; carrying out measures to preserve the soil fertility, protect them from processes of water and wind erosion, salinization, flooding and other degradation processes; development and implementation of integrated plant protection systems from pests, weeds, frosts, drywall, etc.; development and implementation of energy, water and resource-saving technologies for integrated land reclamation, restoration and expansion of irrigation in accordance with predicted climate change; creation and improvement of mechanisms of functioning of insurance, seed, feed and food funds as a basis for minimizing losses from natural phenomena; development and implementation of insurance policies against adverse natural conditions.

4. To reduce the negative impact of agriculture on the environment, namely to ensure minimization of greenhouse gas emissions, it is necessary to ensure: optimization of the timing of sowing and the selection of varieties of agricultural crops; displacement of climatic zones of cultivation of crops; improvement of technologies for cultivating land and pastures for the purpose of conservation and accumulation of carbon in the soil; cultivating energy crops to replace non-renewable fuels; restoration of degraded soils; modernization of collection systems, storage of manure to reduce emissions of CH_4 and NH_3; modernization and implementation of optimal systems for keeping and fattening farm animals; the introduction of technologies for the introduction of nitrogen fertilizers that reduce the emission of N_2O.

Summarizing the above, it can be stated that measures aimed at reducing greenhouse gas emissions are close in their content to measures for adapting agriculture to climate change and promoting the formation of ecological agriculture.

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