UDC 338.43:631.95
DOI: https://doi.org/10.32847/business-navigator.70-17

Tatar Maryna
PhD in Economics, Associate Professor
National Aerospace University "Kharkiv Aviation Institute"

Татар М.С.
кандидат економічних наук, доцент
Національний аерокосмічний університет імені М.Є. Жуковського «Харківський авіаційний інститут»

IMPACT OF CLIMATE CHANGE AS A KEY GLOBAL CHALLENGE ON SOCIAL AND ECONOMIC SYSTEMS INTERACTION

Tatar Maryna. Impact of climate change as a key global challenge on social and economic systems interaction. Climate change is affecting all nations, and given the long-term perspective, neither military conflict nor the socio-behavioral constraints caused by the COVID-19 pandemic can be compared to the impact of environmental risks, including climate change. At the same time countries with low adaptive potential, i.e. limited economic resources, low technology, poor information network, weak infrastructure, unstable or underdeveloped institutions, and unfair access to resources, are characterized by increased vulnerability to climate change. The article is aimed at analyzing the impact of climate on various areas, in particular on population health, agriculture (arable, livestock, and hydrology sectors) and food security, on the energy sector, industry, and so on, which will make possible to understand better which areas, and which sectors of the economy will be affected primarily by the climate, which the scale and the consequences of such influence, which in turn will determine the necessary measures and the cost of adaptation to climate change and accordingly adjust the interaction and cooperation at different levels.

Key words: agriculture, climate change, energy complex, global challenges, impact, industry, interaction, population health, social and economic systems.

Татар М.С. Вплив зміни клімату як ключового глобального виклику на взаємодію соціальних та економічних систем. Зміна клімату впливає на всі країни без виключення, і з огляду на довгострокову перспективу, ані військовий конфлікт, ані соціально-поведінкові обмеження, викликані пандемією COVID-19, не можна порівняти з впливом екологічних ризиків, включаючи зміну клімату. При цьому країни з низьким адаптивним потенціалом, тобто обмеженими економічними ресурсами, нестабільною політичної ситуацією, низькими технологіями, поганою інформаційною мережею, слабкою інфраструктурою, нестабільними або слаборозвиненими інституціями та недостатнім доступом до ресурсів, характеризуються підвищеною вразливістю до зміни клімату. У статті здійснено аналіз впливу клімату на різні сфери, зокрема на здоров'я населення, сільське господарство (рослинництво, тваринництво та гідрологію) й продовольчу безпеку, на енергетику, промисловість тощо, що дасть змогу краще зрозуміти, на які сфери та які сектори економіки зміна клімату вплине першочергово, які масштаби та наслідки такого впливу, що, у свою чергу, визначатиме необхідні заходи та вартість адаптації до зміни клімату та, відповідно, допоможе скоригувати взаємодію та співпрацю на різних рівнях. Так, зміна клімату впливає на сільське господарство через тепловий стрес для рослин, зміну вологості та температури ґрунту, втрату родючості ґрунту через ерозію, зменшення кількості води, доступної для рослинництва, зміни висоти рівня ґрунтових вод, засолення прісноводного водоносного горизонту, втрату частини суші через підвищення рівня моря тощо. Вплив на біорізноманіття полягає у фенологічних змінах і змінах у розподілі видів. Вплив зміни клімату на здоров'я населення проявляється у наявності травм і смертності внаслідок екстремальних погодних явищ, захворювань, пов'язаних із спекою, респіраторних та алергічних захворювань, хвороб, що передаються через воду, та інших впливів на здоров'я, пов'язаних із водою, зоонозів, трансмісивних захворювань, недоїдання та хвороб, що передаються через їжу, неінфекційних захворювань, розладах психічного та психологічного характеру, що в свою чергу впливає на соціально-економічні показники підприємств, пов'язані з частим перебуванням працівників на лікарняному, необхідністю оплати часу непрацездатності працівників, перекладання обов'язків відсутнього працівника на інших працівників, зниженням продуктивності праці тощо. Процес адаптації в природних або людських системах у відповідь на фактичні або очікувані кліматичні впливи зменшить їх негативні наслідки та дозволить скористатися сприятливими можливостями, допомагаючи уникнути катастрофічних наслідків у глобальному масштабі.

Ключові слова: сільське господарство, зміна клімату, енергетичний комплекс, глобальні виклики, вплив, промисловість, взаємодія, здоров'я населення, соціально-економічні системи.

Introduction. Climate change is a major global development challenge with potentially serious threats to the global economy and international security due to increased direct and indirect risks related to energy security, food and drinking water providing, stable ecosystems existence, health and people life standards ensuring. According to World Economic Forum, in recent years the strongest risks are climate action failure, extreme weather, biodiversity loss, and human environmental damage, i.e. environmental risks [1].

Climate change directly affects population health and migration, land resources, agriculture, forestry, biodiversity, water resources, energy, industry, and infrastructure. The most important is climate change for the agricultural sector, which in turn affects food security, quality of life and demographics.

Literature review. Both international organizations, authorities, and individual researchers are engaged in the study of climate change and its impact on various social and economic systems. World Health Organization conducted a study aimed at enhancing the capacity of health care facilities to protect and improve the health of their target communities in an unstable and changing climate; and empowering health care facilities to be environmentally sustainable, by optimizing the use of resources and minimizing the release of waste into the environment. Climate-resilient and environmentally sustainable health care facilities contribute to high quality of care and accessibility of services, and by helping reduce facility costs also ensure better affordability [2].

Timothy B. Sulser, Keith Wiebe, Shahnila Dunston, Nicola Cenacchi, Alejandro Nin-Pratt, Daniel Mason-D'croz, Richard Robertson, Dirk Willenbockel, and Mark W. Rosegrant assess the cost of adaptation to climate change across a range of future climate scenarios and investment options. They focus on offsetting climate change impacts on hunger through investment in agricultural research, water management, and rural infrastructure in developing countries. They link climate, crop, water, and economic models to analyze scenarios of future change in the agriculture sector to 2050 and assess trade-offs for these investments across key Sustainable Development Goals (SDGs) for poverty, hunger, and water. Their research shows that climate change slows progress toward eliminating hunger, with an additional 78 million people facing chronic hunger in 2050 relative to a no-climate-change future, over half of them in Africa south of the Sahara. Increased investments can offset these impacts [3].

Colin Carter, Xiaomeng Cui, Dalia Ghanem, Pierre Mérel identify the economic impacts of climate change on agriculture. Cross-sectional and panel regression analysis are the most commonly used methods to infer climate impacts on agriculture while accounting for the behavioral response of humans. The former seeks to correlate cross-sectional differences in climate to agricultural outcomes and thus implicitly accounts for long-run adaptation to climate change, however it falls short on causal identification due to the likely presence of omitted variables. The latter features a cleaner identification strategy but may only partially capture long-run adaptive behavior. In their article the authors focus on important methodological issues that arise in the context of estimating climate change impacts from panel data [4].

James A. Rising, Charlotte Taylor, Matthew C. Ives, Robert E.T. Ward made a summary of key dimensions in the economic evaluation of climate risks [5]. They say that economic assessments of climate change risks are intended to be comprehensive, covering the full range of physical impacts and their associated market and non-market costs, considering the greater vulnerability of poor people and the challenges of adaptation.

Despite the fact that many organizations and individual researchers are engaged in the problem of climate change, the problem remains extremely relevant. Requires a detailed analysis of the impact of climate on various areas, in particular on public health, agriculture and food security, the energy sector, industry, and so on, which will make it possible to understand better which areas, and which sectors of the economy will be affected primarily by the climate, which the scale and the consequences of such influence, which in turn will determine the necessary measures and the cost of adaptation to climate change and accordingly adjust the interaction and cooperation at different levels.

The purpose of the article is determination the impact of climate change on social and economic systems interaction and identification areas that are most susceptible to climate change and determination the scale of impacts on these areas and activities.

The statement of basic materials. Worldwide, winters and summers alike are becoming increasingly hotter than the 1951–1980 average (Table 1). With 1.7°C more than the reference average for the world, 2020 was the warmest year at the global level; 2016 had the second highest global mean annual temperature change [6].

Europe is the region where the temperature change has been the highest in 2020 (and also for most of the 2000–2020 period), with 3.4°C, followed by Asia (1.6°C), Oceania (1.4°C), the Americas and Africa (1.3°C). The average temperature change in the 2010s was 1.26°C, com-

Table 1

Temperature change by region

Year	Region					
	Europe	World	Asia	Oceania	Americas	Africa
2000	1,349	0,732	0,695	0,138	0,724	0,481
2001	0,959	0,835	1,034	0,322	0,84	0,671
2002	1,511	1,015	1,182	0,681	0,769	0,886
2003	0,977	0,895	0,66	0,742	0,983	1,003
2004	1,289	0,916	1,104	0,621	0,675	0,842
2005	1,545	1,109	0,884	1,088	1,025	1,126
2006	0,689	1,004	1,123	0,624	1,215	0,945
2007	2,321	1,199	1,209	0,821	0,92	0,816
2008	2,036	0,937	0,899	0,548	0,57	0,744
2009	1,246	0,961	1,096	0,894	0,678	1,003
2010	0,823	1,22	1,272	0,641	1,299	1,527
2011	1,555	0,925	0,724	0,181	0,854	0,958
2012	1,798	1,081	0,721	0,24	1,332	0,809
2013	1,13	1,023	1,081	1,378	0,837	1,03
2014	1,846	1,059	0,939	1,081	0,713	1,037
2015	2,13	1,424	1,314	0,984	1,341	1,228
2016	2,305	1,668	1,489	1,14	1,743	1,414
2017	1,987	1,438	1,495	1,087	1,317	1,218
2018	2,027	1,301	1,373	1,077	0,945	1,206
2019	2,116	1,463	1,425	1,348	1,228	1,347
2020	3,365	1,719	1,56	1,364	1,318	1,254

Source: developed by the author on the bases of [6]

pared to 0.96°C in the 2000s. As seen in Table 57, more than 150 countries had a mean annual temperature change at least 1.0°C higher than the 1951–1980 average in 2020; the largest mean annual temperature change was recorded in the Russian Federation (3.7°C).

Climate change can be caused by climatic changes over time, caused not only by human activity, but also by natural processes, and directly or indirectly caused by human activity, its eco-destructive impact on the environment (in particular, due to the burning of fossil fuels (oil, gas, coal), the growth of emissions from the transport, industry, and intensive agriculture, etc.), which generates changes in the global atmosphere and is superimposed on the natural climate fluctuation observed during comparative periods of time.

According to the report of the Intergovernmental Panel on Climate Change, scientific studies show that climate change as a result of anthropogenic influence since the end of the 19th century is only about one-third due to natural changes, and two-thirds is caused by human activity, in particular the increase concentrations of greenhouse gases in the atmosphere.

The Intergovernmental Panel on Climate Change (IPCC) has concluded that to avert catastrophic health impacts and prevent millions of climate change-related deaths, the world must limit temperature rise to 1,5°C. Past emissions have already made a certain level of global temperature rise and other changes to the climate inevitable. Global heating of even 1,5°C is not considered safe, however; every additional tenth of a degree of warming will take a serious toll on people's lives and health [2].

Pollution of the natural environment caused by human actions affects both climate changes in the long term and social and demographic indicators, leads to exacerbation of chronic human diseases, rejuvenation of some diseases, increase in the probability of mutation of some diseases, which strengthens the negative consequences of another global challenge like the COVID-19 pandemic, when people with chronic diseases were at risk of increased mortality.

Climate change affects health and migration. Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter. According to the estimates of the World Health Organization, between 2030 and 2050, climate change is expected to cause approximately 250000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress. The direct damage costs to health (i.e. excluding costs in health-determining sectors such as agriculture and water and sanitation), is estimated to be between 2-4 billion USD per year by 2030 [2].

The impacts of climate change on health and the healthcare system are presented in Figure 1.

The significance of the impact of climate change on health depends on the level of adaptability of communities to negative changes in the external environment. At the same time, the quantitative and qualitative characteristics of these changes differ significantly depending on the place of living, the initial environment state, the spread of "green technologies" and the environmental awareness of citizens. The level of sensitivity of people to the negative consequences of climate change largely depends on the

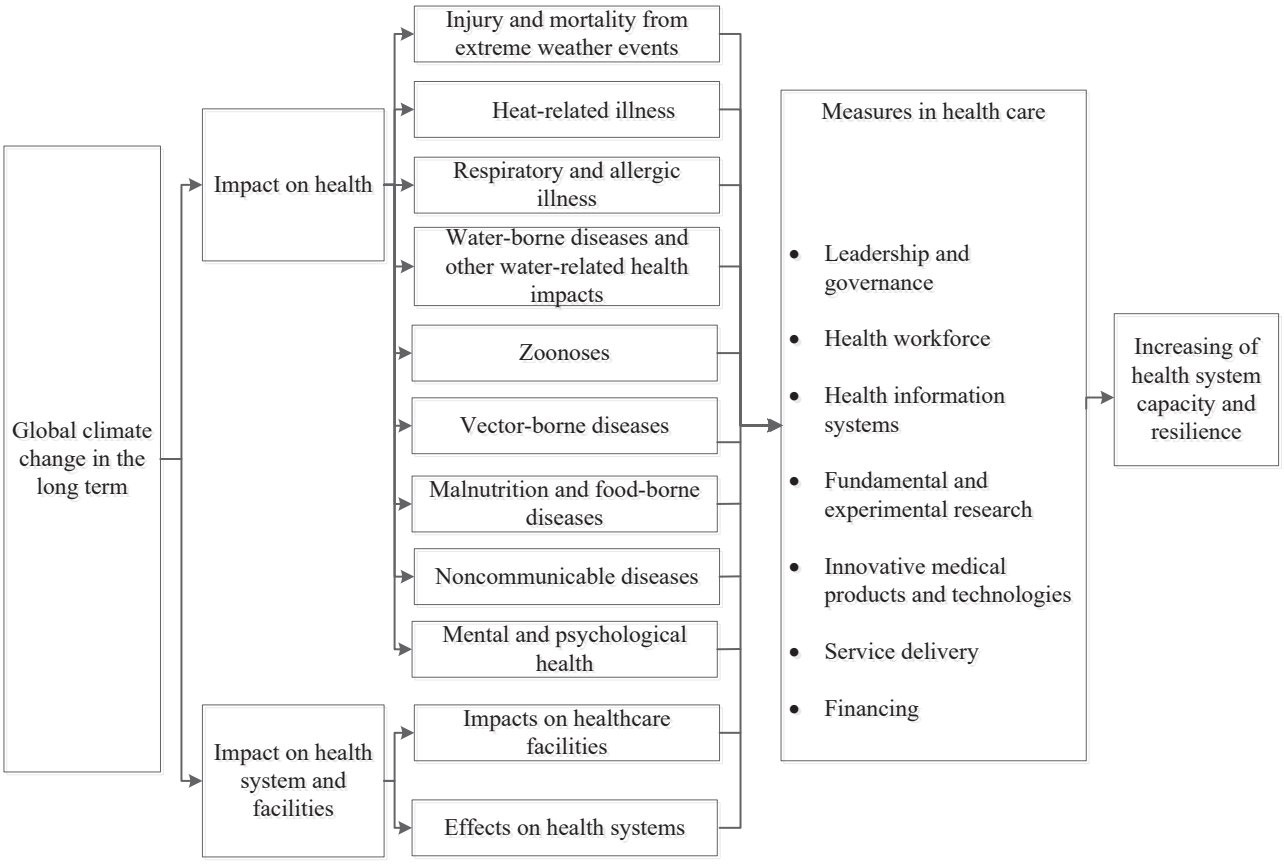

Figure 1. The impacts of climate change on health and the healthcare system

Source: developed by the author on the bases of [7]

individual characteristics of the functioning of the body, the presence of acute and chronic diseases. However, people of the oldest age groups and children are most prone to exacerbation of negative conditions.

Social and economic factors of life support (nature and scope of employment, leading a healthy lifestyle, availability of access to quality food and clean drinking water) largely determine the level of resistance of both individuals and social groups to the negative factors of climate change.

Climate change leads to an increase in the number of days when extremely high temperatures are observed in the moderate continental climate prevailing in Europe. This has negative consequences for public health in the context of increased cardiovascular risks and even sudden death caused by overheating. This is especially true for children, the elderly, people with chronic illnesses, and workers who work outdoors. For children under one year of age, overheating can cause death due to sudden body dehydration. Western scientists have proven that during periods when abnormally high temperatures persist for several days in a row or longer, there is a significant increase in the number of deaths related to this phenomenon in cities, especially due to exacerbation of chronic cardiovascular diseases. Due to a number of factors, diseases of the cardiovascular system are not only the main cause of death in general, but also the most frequent cause of premature mortality of middle-aged people (especially men). In this context, the manifestations of climate change will deepen the negative trends in the formation of the age profile of mortality.

An important factor in morbidity and mortality due to temperature rise is the formation and preservation of favorable conditions for the spread of infectious agents, in particular those that cause acute intestinal infections in humans. In the risk group: children who are in organized children's collectives, persons from low-income households in which the minimum sanitary and hygienic standards of life are not maintained, as well as population groups prone to consumption of low-quality food products.

Less critical, but significant in the long term, is the increase in fatigue and stress caused by high temperatures, and as a result, the number of mental illnesses in the population, weakening of resistance to infectious diseases.

An increase in the average air temperature leads to a lengthening of the flowering period, when there is a significant amount of allergen plant pollen in the air, which negatively affects the life quality of people with allergies and asthma. Over the past 30 years, allergic diseases have become one of the most common ailments in the world. As a result, socio-economic indicators are deteriorating, in particular the periods of incapacity for work for people suffering from allergies increase and labor productivity and economic indicators of enterprises are declining. Also the quality of education decreases because children are prone to allergies more than adults.

In addition, for people with chronic asthma and allergies, the risk of developing or complicating acute respiratory conditions increases, which is a significant factor in premature mortality especially in low-income countries.

Thus, extending the period of exposure to allergens on the health of the population can significantly affect the general level of working capacity and economic indicators as a result. Climate change leads to an increase in the concentration of ground-level ozone, a component of urban smog, which can quickly be carried by air currents to a distance of up to 1000 km. This substance provokes the emergence of asthma, manifestations of allergies, causes lung emphysema and a general decrease in immunity.

Due to the noticeable generally toxic, irritating, carcinogenic, mutagenic, genotoxic effect of surface ozone on the human body, the WHO classifies it as an environmental parameter subject to constant monitoring. Climate change is one of the key factors in increasing drought which is the main cause of natural fires.

An increase in the number of natural fires also negatively affects air quality and, accordingly, the health of the population.

An abnormally warm winter can lead to a shortage of water resources and an increase in the number of natural fires. Fires lead to significant air pollution in the regions. Consequences of warming for population health are presented in Table 2.

During the analysis of the causes of death in various countries of the world, it can be concluded that the main ones are diseases of the circulatory system and neoplasms. For example, in the Slovak Republik in the first place are diseases of the circulatory system, in particular ischaemic heart diseases, cerebrovascular diseases (46%), in the second place are neoplasms (23,74%), in the third place are diseases of the respiratory system (6,41%) [8]. In Ukraine is also on the first place are diseases of the circulatory system (68,62%), in the second place are neoplasms (13%), in the third place are external causes of mortality (4,81%), among which the largest share is taken intentional self-harm [9; 10].

Because abnormally high temperature can lead to increase in the number of deaths from coronary heart disease and other cardiovascular diseases, diabetes, suicides, murders, traffic accidents, mental disorders, then the situation will worsen in the future.

The environmental pollution and climate change, in addition to health, also affect energy, industry, and infrastructure. The fuel and energy complex is traditionally considered the industry with the most significant impact on climate change as the main source of greenhouse gases. But the energy sector is also the most vulnerable to climate change due to the peculiarities of its functioning, which are related to natural and climatic conditions and the need for a significant transformation to ensure the adaptation of the fuel and energy complex (Figure 2).

The impact of climate change on thermal power plants is expressed in a decrease in their overall thermal efficiency due to an increase in average annual temperatures, as well as in the heating and drying of nearby cooling reservoirs. As an alternative, the IAEA suggests reuse of process water (closed water circulation systems) or more expensive dry cooling technologies. Renewable energy is critically important from the point of view of decarbonizing the electricity system and mitigating the effects of anthropogenic climate change. However, renewable energy currently accounts for no more than 25% of the world's generating capacity, with hydropower accounting for 16% and solar and wind power stations accounting for about 5%.

The vulnerability of hydropower is the change in river water level and temperature due to global warming.

The resource base of wind power plants is also strongly influenced by temperature changes, as low air density due to high average annual temperatures leads to a decrease in their output power. An effective solution to the problem

Table 2

Consequences of warming for population health

Nature of influence and risk factor	Health impact	Risk assessment
Abnormally high temperature in cities (direct influence)	Excess heat-related mortality; increased incidence of heat exhaustion and heat stroke; exacerbated circulatory, cardiovascular, respiratory and kidney diseases; increased premature mortality related to ozone and air pollution produced by fires, particularly during heat waves. An increase in the number of deaths from coronary heart disease and other cardiovascular diseases, diabetes, suicides, murders, traffic accidents, mental disorders.	Very high
Higher temperatures and humidity; changing and increasingly variable precipitation; higher sea surface and freshwater temperatures	Accelerated microbial growth, survival, persistence, transmission; shifting geographic and seasonal distribution of diseases (such as cholera, schistosomiasis); ecological changes, droughts and warmer temperatures leading to cyanobacterial blooms, pathogen multiplication; extreme events leading to disruption of water supply system and contamination; insufficient or intermittent water access for health care practices; insufficient quality and quantity of water leading to poor hygiene; flood damage to water and sanitation infrastructures; contamination of water sources through overflow.	Very high
An increase in the concentration of pollutants in the air (indirect effect)	An increase in the number of cases of cardiovascular and respiratory diseases. Spread of bronchial asthma, bronchitis, other diseases of the respiratory and ENT organs, allergies.	Average
Higher temperatures and humidity; changing and increasingly variable precipitation. Expansion of wetlands, fodder base and breeding places for mosquitoes, tick habitat, changes in areas of natural foci of infections	Accelerated parasite replication and increased biting rates; prolonged transmission seasons; re-emergence of formerly prevalent diseases; changing distribution and abundance of disease vectors; reduced effectiveness of vector control interventions. An increase in the number of diseases such as malaria, West Nile fever, Crimean-Congo fever, tick-borne encephalitis and borreliosis, rickettsiosis, leptospirosis, tularemia and other infectious and parasitic diseases.	Average
Storms, floods, hurricanes, typhoons and other natural disasters (direct effect, remote effect)	Fatalities, injuries; post-traumatic shock, stress, mental disorders.	High, Average
The influence of high temperature on the state of the causative agents of intestinal infectious diseases and parasitosis, disruption of water supply and sewage facilities	An increase in the number of intestinal infections such as dysentery, typhoid, hepatitis A, salmonellosis, lambiosis, cryptosporidiosis, etc.	High
Higher temperatures and humidity	Outdoor and unprotected health workers obliged to work either in physiologically unsafe conditions or to lose income and livelihood opportunities.	High
Higher temperatures and changes in precipitation. A decrease in the productivity of agricultural production and the calorie content of food	Lower food production in the tropics; lower access to food due to reduced supply and higher prices; combined effects of undernutrition and infectious diseases; chronic effects of stunting and wasting in children. Increase in the number of people with a low body mass index, increase in the number of people suffering from obesity due to unbalanced nutrition.	High

Source: developed by the author on the bases of [7]

is the improvement of wind resource assessment methods. Accounting for random changes in energy planning and establishing sufficient reserve capacities are the main options for adaptation. A gradual weather change, in particular the relative humidity, will affect the frequency of icing of the blades of both onshore and offshore wind power plants. A partial solution to the problem can be a change in the design of the blades or an internal heating.

A similar situation with solar energy. Climate change affects the cloudiness and insolation of different regions, as well as the production of solar energy. An increase in average annual temperatures also increases the productivity of solar heating systems, especially in cold regions, but at the same time reduces the efficiency of photovoltaic conversion.

The consequences of climate change affect all sectors of the economy, including industry, primarily by changing the basic physical characteristics of the environment and determining the scarcity of resources. Global climate change has direct and indirect impacts on the industrial sector. Direct impacts are associated with a direct change in natural and climatic conditions due to a change in the pattern of energy consumption and the availability of natural resources due to the difficulty of access to minerals, as a result of an increase in the risk of man-made emergency situations, an insufficient amount of water resources of appropriate quality, etc. Indirect impacts are caused by changes occurring in related industries and consist in a change in the economic conditions of operation due to the dependence of processing enterprises on management schemes in agriculture and forestry. The vulnerability of industrial enterprises and infrastructure facilities to soil erosion, floods, sea level rise and associated changes in the wave regime will increase significantly.

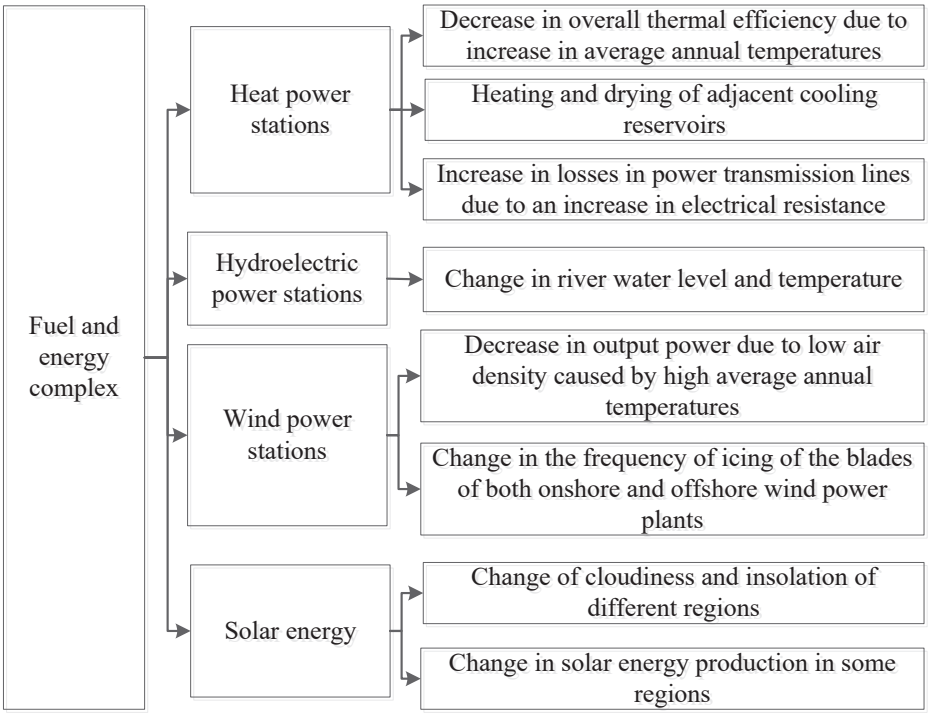

Figure 2. Impact of climate change on the fuel and energy complex

Source: developed by the author on the bases of [2; 7]

Floods and inundation are a threat of a significant negative impact on infrastructure objects due to their damage and destruction, which in turn will cause the destruction of logistics and resource-energy schemes. An increase in the number and frequency of dangerous meteorological phenomena will cause an increase in the vulnerability of industrial facilities, an increase in accidents and the frequency of their repairs, which will lead to a corresponding increase in material and financial costs. An increase in temperature will be a factor in increasing product storage costs, especially for the food industry, and will cause an increase in the threat of fires and deformation risks, especially for spatially distributed objects.

The climate change impact on agriculture and as a result on food security because the country's food security directly depends on the agriculture development. At the same time, it should be noted that in 2020 nearly 690 million people – or 8.9 percent of the global population – are hungry, up by nearly 60 million in five years. The food security challenge will only become more difficult, as the world will need to produce about 70 percent more food by 2050 to feed an estimated 9 billion people.

Without adaptation measures, climate change could reduce global agricultural growth by up to 30% by 2050. The 500 million small farms around the world will be most affected. The number of people without adequate water for at least one month of the year will increase from 3.6 billion today to more than 5 billion by 2050. Rising sea levels and increased storm surges could force hundreds of millions of people in coastal cities to flee their homes, and total damage to coastal urban areas could exceed $1 trillion each year by 2050 year [2].

The challenge is intensified by agriculture's extreme vulnerability to climate change. Climate change's negative impacts are already being felt, in the form of increasing temperatures, weather variability, shifting agroecosystem boundaries, invasive crops and pests, and more frequent extreme weather events. On farms, climate change is reducing crop yields, the nutritional quality of major cereals, and lowering livestock productivity. Substantial investments in adaptation will be required to maintain current yields and to achieve production and food quality increases to meet demand.

Climate change is very likely to affect food security at the global, regional, and local level. Climate change can disrupt food availability, reduce access to food, and affect food quality. For example, projected increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability may all result in reduced agricultural productivity. Increases in the frequency and severity extreme weather events can also interrupt food delivery, and resulting spikes in food prices after extreme events are expected to be more frequent in the future.

Impacts of climate change on agriculture are presented in Figure 3. Climate change leads to changes in arable, livestock and hydrology sectors.

At first, let's consider impacts on arable sector. Changes in temperature, atmospheric carbon dioxide (CO_2), and the frequency and intensity of extreme weather could have significant impacts on crop yields. For any particular crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction. In some areas, warming may benefit the types of crops that are typically planted there, or allow farmers to shift to crops that are currently grown in warmer areas. Conversely, if the higher temperature exceeds a crop's optimum temperature, yields will decline.

Higher CO_2 levels can affect crop yields. Some laboratory experiments suggest that elevated CO_2 levels can increase plant growth. However, other factors, such as changing temperatures, ozone, and water and nutrient constraints, may counteract these potential increases in yield. Dealing with

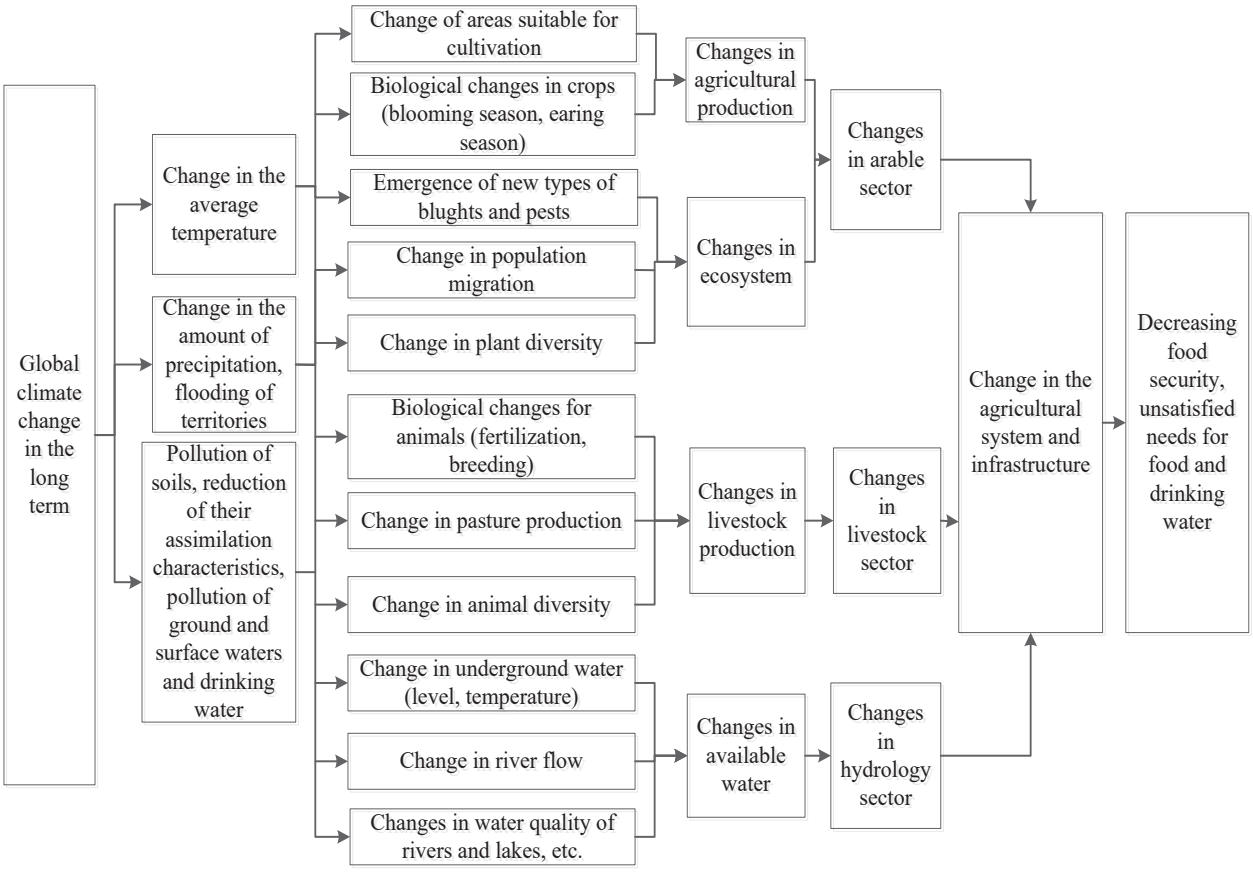

Figure 3. The impacts of climate change on agriculture

Source: developed by the author on the bases of [11]

drought could become a challenge in areas where rising summer temperatures cause soils to become drier. Although increased irrigation might be possible in some places, in other places water supplies may also be reduced, leaving less water available for irrigation when more is needed [6].

Many weeds, pests, and fungi thrive under warmer temperatures, wetter climates, and increased CO_2 levels. Though rising CO_2 can stimulate plant growth, it also reduces the nutritional value of most food crops. Rising levels of atmospheric carbon dioxide reduce the concentrations of protein and essential minerals in most plant species, including wheat, soybeans, and rice. This direct effect of rising CO_2 on the nutritional value of crops represents a potential threat to human health. Human health is also threatened by increased pesticide use due to increased pest pressures and reductions in the efficacy of pesticides [2].

Thus, examples of the impact of climate change on biodiversity can be:

– phenological changes – when the average temperature increases by 20°C, plants begin to bloom 5-30 days earlier, when there is a threat of frost and there are still no pollinating insects, which causes a negative effect;

– changes in the distribution of species, i.e. change in the range due to a change in conditions leads to the rapid appearance and distribution of invasive species, including many dangerous weeds, allergens, poisonous, etc. Invasive species are usually more durable and gradually completely replace local ones, for example, ragweed and borscht, which pose a significant threat to public health [6].

Three types of reactions of biota to climate change are identified: migration, adaptation and extinction (disappearance) (Table 3).

Further let's consider impacts on livestock sector. Heat waves, which are projected to increase under climate change, could directly threaten livestock. Heat stress affects animals both directly and indirectly. Over time, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production.

Drought may threaten pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from higher summer temperatures and reduced precipitation. For animals that rely on grain, changes in crop production due to drought could also become a problem.

Climate change may increase the prevalence of parasites and diseases that affect livestock. The earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily. In areas with increased rainfall, moisture-reliant pathogens could thrive.

Potential changes in veterinary practices, including an increase in the use of parasiticides and other animal health treatments, are likely to be adopted to maintain livestock health in response to climate-induced changes in pests, parasites, and microbes. This could increase the risk of pesticides entering the food chain or lead to evolution of pesticide resistance, with subsequent implications for the safety, distribution, and consumption of livestock and aquaculture products.

Table 3

Characteristics of types of biota reactions to climate change

Reaction	Characteristics
Migration	Under normal conditions, it is an ecologically balanced process, but due to the increase in the rate of changes in the environment and the presence of anthropogenic obstacles (ecological holes), the balance is disturbed. Invasive species displace natives and occupy their econiches, breaking coevolutionary ties. Accordingly, the species that we would like to see in nature migrate often.
Adaptation	Evolution is a long process, and today's climate is changing faster than evolutionary possibilities. This leads to the vulnerability of species with a long development cycle (perennials) and their replacement, in particular, by annual weeds. On a global scale, this leads to the reduction of energy reserves in the biomass of ecosystems and, in the final case, to the disruption of the energy pyramid. For the conditions of Europe, the risk of settling unproductive annuals is very high.
Extinction	The most negative process. It is predicted that within a century, 17–35% of species will disappear from certain territories, and in Europe, in particular, by 2080, about 50% of plant species will reduce their range.

Source: developed by the author on the bases of [6; 11]

Increases in carbon dioxide (CO_2) may increase the productivity of pastures, but may also decrease their quality. Increases in atmospheric CO_2 can increase the productivity of plants on which livestock feed. However, the quality of some of the forage found in pasturelands decreases with higher CO_2. As a result, cattle would need to eat more to get the same nutritional benefits.

Conclusion. Thus, the article proves that climate change affects the social and economic systems on a global scale and can lead to significant consequences. Climate change increases the risks for the health of the population, ecosystems, water and forest resources, the sustainable functioning of the energy infrastructure and the agricultural complex, which can cause and is already causing colossal losses. Climate hazards will affect agriculture through heat stress on plants, changes in soil moisture and temperature, loss of soil fertility through erosion of top soil, less water available for crop production, changes in height of the water table, salinization of the freshwater aquifer, loss of land through sea level rise, etc. The influence on biodiversity can be in phenological changes and changes in the distribution of species. Climate change could lead to injury and mortality from extreme weather events, heat-related illness, respiratory and allergic illness, water-borne diseases and other water-related health impacts, zoonoses, vector-borne diseases, malnutrition and food-borne diseases, noncommunicable diseases, mental and psychological health which in turn affects the economic indicators associated with the frequent departure of employees on sick leave, the need to pay for the time of disability of employees, a decrease in labor productivity, etc.

Due to the fact that climate change is one of the greatest threats to humanity, with far-reaching impacts on society, the environment, and the economy and affects all regions of the world and all segments of the population the urgent measures are needed to adapt to climate change and minimize its consequences.

The process of adaptation in natural or human systems in response to actual or expected climatic impacts will reduce their negative consequences and take advantage of favorable opportunities helping avoid global catastrophic consequences on a global scale. Therefore, further research will be aimed at analyzing methods for adapting socio-economic systems of different levels to climate change.

References:

1. The Global Risks Report 2022. Available at: https://www.weforum.org/reports/global-risks-report-2022/ (accessed 28 October 2022).

2. WHO guidance for climate-resilient and environmentally sustainable health care facilities (2020). Available at: https://www.who.int/publications/i/item/9789240012226 (accessed 28 October 2022).

3. Sulser T., Wiebe K., Dunston S., Cenacchi N., Nin-Pratt A., Mason-D'Croz D., Robertson R., Willenbockel D., Rosegrant M. (2021) Change and hunger estimating costs of adaptation in the agrifood system. *IFPRI,* pp. 62. Available at: https://www.ifpri.org/publication/climate-change-and-hunger-estimating-costs-adaptation-agrifood-system (accessed 28 October 2022).

4. Carter C., Xiaomeng C., Ghanem D., Mérel P. (2018). Identifying the Economic Impacts of Climate Change on Agriculture. *Annual Review of Resource Economics,* p. 25. Available at: https://www.webofscience.com/wos/woscc/full-record/WOS:000447824600018 (accessed 28 October 2022).

5. Rising J., Taylor C., Ives M., Ward R. (2022) Challenges and innovations in the economic evaluation of the risks of climate change. *Ecological Economics,* no. 197(2022). Available at: https://www.webofscience.com/wos/woscc/full-record/WOS:000795918600003 (accessed 28 October 2022).

6. Food and Agriculture Organisation of the United Nations. Statistical Yearbook. World Food and Agriculture 2021. Available at: https://www.fao.org/3/cb4477en/cb4477en.pdf (accessed 28 October 2022).

7. WHO. Checklists to assess vulnerabilities in health care facilities in the context of climate change (2021). Available at: https://policycommons.net/artifacts/1455502/checklists-to-assess-vulnerabilities-in-health-care-facilities-in-the-context-of-climate-change/2090343/ (accessed 28 October 2022).

8. Statistical yearbook of the Slovak Republic 2021. Available at: https://slovak.statistics.sk/wps/portal/ (accessed 28 October 2022).

9. The State Statistics Committee of Ukraine. Available at: http://ukrstat.gov.ua (accessed 28 October 2022).

10. Ministry of Environmental Protection and Natural Resources of Ukraine. Available at: https://mepr.gov.ua/en/ (accessed 28 October 2022).

11. Chang-Gil K. The Impact of Climate Change on the Agricultural Sector: Implications of the Agro-Industry for Low Carbon, Green Growth Strategy and Roadmap for the East Asian Region, pp. 50. Available at: https://www.unescap.org/sites/default/files/5.%20The-Impact-of-Climate-Change-on-the-Agricultural-Sector.pdf (accessed 28 October 2022).