

Global climate change and sustainable agricultural development

Andrey Novikov^{1,*}, Vladimir Urazgaliev¹ and Natalya Gagulina²

ABSTRACT

Research background: The problem of global climate change, identified in the middle of the last century, has not yet been resolved. The relevance of the topic is due to the need to find new opportunities for sustainable development of agriculture that can lead to a positive long-term effect. The study is based on the study and analysis of ongoing and expected climate changes, global trends in sustainable development.

Purpose of the article: The aim of the study is to review climate change in relation to the results of decisions on the transition to sustainable development, opportunities and threats to the transformation of agriculture in the context of quality of life.

Methods: The work is based on general methodological principles of the system approach, application of methods of comparative analysis, specification, generalisation, formalisation. Collection, analysis and generalisation of necessary information were used as practical research methods. In the course of the work, statistical information presented on the official website of Russian Statistic Department was used.

Findings & Value added: An analysis of sustainable development reporting has shown that the complex of global environmental, climatic and social problems remains unresolved in the context of increasing climate change and the aggravation of geostrategic contradictions. The key trends that have determined and will determine in the future the dynamics of global agricultural production are of decisive importance for the quality of life of current and future generations.

Keywords: Climate change; sustainable development; agriculture; quality of life

JEL Classification: L2; R13; O13

1 Introduction

The UN Agenda 2030, which includes 17 goals (SDGs) and 169 targets of sustainable development, as well as a number of international documents accompanying this agenda, have formed a long-term framework for actions

* Corresponding author: a-novikov08@mail.ru

¹ Saint Petersburg State University, Faculty of Economics, Department of Economics and Economic Policy, Tchaikovskogo str. 62, a. 310, Saint Petersburg, 191194, Russia

² Institute for Regional Economic Studies, Russian Academy of Sciences Leading researcher 38, Serpuhovskaya str., Saint Petersburg, 190013, Russia

aimed at mitigating the accumulated and expected economic, social, environmental and climatic problems in the foreseeable future (Support for Sustainable Development, 2023).

The results of many years of research into sustainable development problems serve as a justification for the efforts that the world community is making to achieve the SDGs and solve each of the tasks corresponding to them. At the level of states participating in the UN Agenda 2030, sustainable development strategies have been adopted, a number of relevant measures and activities have been developed and are being undertaken.

At the same time, of the 169 mentioned targets, by 2023, satisfactory progress has been achieved only in 18% of them, 67% showed partial but insufficient progress, and 15% demonstrated regression (United Nations, 2023). The current situation forces us to take a fresh look at the problems of sustainable development, their interrelationships and interdependence, and to reconsider approaches to solving each of the identified problems.

The growing aggravation of the situation in each of the subsystems of the planetary socio-ecological-economic system brings to the forefront the conduct of research in the context of the interrelationship of sustainable development problems. In this regard, it seems particularly relevant to analyse the relationship between climate change and some of the tasks set within the framework of SDG 2: End hunger, ensure food security, improve nutrition and promote sustainable agriculture.

The aim of the study is to review climate change in relation to the results of decisions on the transition to sustainable development, key trends that determine the dynamics of global agricultural production, opportunities and threats to agriculture in the context of quality of life (Novikov and Gregova, 2017). To achieve this goal, it is necessary to analyse evidence of climate change, compare it with key trends that determine the situation in global agriculture and draw conclusions about changes in the quality of life in connection with possible transformations.

The study is based on the general methodological principles of a systems approach, which made it possible to apply a model of a socio-ecological-economic system in the analysis, the use of methods of comparative analysis, specification, generalisation, and formalisation. The collection, analysis, and generalisation of the necessary information on climate change and the situation in the agro-industrial sector were used as practical research

methods. In the course of the work, statistical information presented on the official website of Russian Statistic Agency and in other open sources of information was used.

2 Methods

2.1 Review of climate change in relation to the results of decisions on the transition to sustainable development

Climate change is manifested in an increase in atmospheric temperature and precipitation, rising sea levels, a reduction in ice cover in the polar regions, degradation of permafrost soils, an increase in the frequency and intensity of extreme weather and climate events, including floods, hurricanes and heat waves.

Climate change has been closely monitored by the world community for several decades. The largest global climate observing system (GCOS, Global Climate Observing System (GCOS)) was created in 1992. The functioning of this system is ensured by the joint actions of such organisations as the Integrated Global Observing System of the World Meteorological Organization (WMO) (WMO Integrated Global Observing System (WIGOS)), the Global Cryosphere Watch (GCW) and the World Hydrological Cycle Observing System (WHYCOS), as well as the Global Ocean Observing System (GOOS).

The implementation of climate change monitoring is based on a list of 50 key climate variables defined by GCOS to create and update global climate products and derived information. Thus, lightning discharges, clouds, the Earth's radiation balance, wind speed and direction, temperature, water vapour, atmospheric air components: carbon dioxide CO₂, methane CH₄ and other greenhouse gases, ozone O₃, aerosols, precursors of ozone and aerosols, etc. are subject to constant observation in the atmosphere. Precipitation, atmospheric pressure, wind speed and direction, etc. are observed in the surface layer. This is only a small part of the full list of indicators, data on which are available in the global climate observation system.

The large scale of climate observations is the source of data for continuously expanding and improving data archives and reanalyses conducted at the global level by a number of US, European and Japanese organisations, including: NOAA GlobalTemp (US National Oceanic and Atmospheric

Administration, NOAA), GISTEMP v4 (US National Aeronautics and Space Administration, NASA), CRUT4 and CRUTEM4 (UK Met Office Hadley Centre and Climate Research Unit, University of East Anglia and UK Met Office), CRU TS (University of East Anglia Climate Research Unit and UK Met Office), MERRA-2 (US National Aeronautics and Space Administration, NASA), ERA5 (European Centre for Weather Forecasts), JRA-55 (Japan Meteorological Agency), CEP/NCAR (a joint product of the National Centers for Environmental Prediction and the National Center for Atmospheric Research), DEL (University of Delaware, USA).

As the results of observations obtained in the course of the work of the listed organisations show, the human impact on the climate system is gradually increasing (GCOS WMO). This problem has received wide worldwide recognition and is one of the most powerful global challenges, which the sustainable development mechanism developed at the international level is aimed at overcoming. Of particular concern is the accumulation of concentrations of three greenhouse gases in the atmosphere, which have increased significantly since the pre-industrial era: CO₂ (by 46%), CH₄ (by 157%), and N₂O (by 22%), despite the efforts being made at the international level to reduce them. At the same time, the content of CO₂ and N₂O in the atmosphere has increased monotonically in recent decades, and the concentration of methane in 2000–2007 increased by 0.6% over eight years and then resumed its growth. According to hydrometeorological observations, the average global temperature in 2011–2020 was 1.10 ± 0.12 °C above the pre-industrial level and continues to increase: 2023 became the warmest year, January 2024 – the warmest winter month in the entire history of meteorological observations. In a number of regions of the world: Europe, South Africa, Mexico and others, twice as many extremely hot days were recorded in 2011–2023 as in 1961–1990.

The sea level rise values in 2011–2020 (4.5 ± 0.6 mm/year) were almost twice as high as in the previous decade 2001–2010 (2.9 ± 0.5 mm/year) (WMO, 2023). According to the European Climate Change Service Copernicus, the summer of 2024 was the hottest on record. It can be expected that the whole of 2024 will also be a record-breaking year in terms of the number of temperature anomalies: over the three summer months of 2024, the average temperature on Earth was +16.8 degrees Celsius. This is 0.03 more than it was in the summer of 2023, when the previous record was recorded, but not all

summer months were extremely hot: July last year was hotter than in 2024. In August, the weather was the same as a year ago: (+16.82) degrees.

It should be noted that progressive climate change is not the only problem of sustainable development that is far from an acceptable solution. There are many contradictions in connection with the transition to sustainable development. These include insufficient scientific knowledge about the mechanisms of ecosystem and climate functioning compared to the scale of such mechanisms, and the slow pace of development of technologies applicable to achieving the established sustainable development goals (hereinafter referred to as SDGs), and the competing interests of various groups of countries and economic agents that slow down the achievement of the SDGs, etc. According to expert estimates, in 2023, the pace required to achieve the SDGs set by 2030 was not achieved for any of these goals by the global community as a whole. With respect to 11 SDGs (65% of their total number), progress was insignificant (partial), and the remaining 6 SDGs (35%) were stagnant or even moving backwards.

Here are just some of the data that show the worsening problems of sustainable development in the world.

In 2022, 2.4 billion people (29.6% of the world's population) lacked adequate nutrition, approximately 735 million people (9.2% of the world's population) suffered from chronic hunger. In 2023, more than 4 billion people in the world were not covered by any social assistance programmes (United Nations, 2023). More than a quarter of the world's population (about two billion) do not have access to clean drinking water, which is all the more alarming, since we are talking about a truly critical resource that is the basis of human life. Almost half of people (46%) do not have access to safe sanitation services, which is why more than 1,000 children under 5 die every day. According to forecasts, by 2030, 575 million people will live below the poverty line (7% of the world's population), and only a third of countries will be able to reduce poverty levels by at least half in the next five years.

According to The World Bank, the source of significant damage, estimated at more than \$8 trillion (6.1% of global GDP in PPP), is environmental pollution. At the same time, 85% of the damage is due to additional mortality, 15% – morbidity (The World Bank, 2022). Against this background, special attention is paid to climate change. The problem of climate change and its most striking manifestation – the accumulation of greenhouse gases

in the atmosphere, together with other problems of sustainable development, some of which we mentioned above, draws attention to the situation that is developing in the sphere of global agricultural production. Some experts associate the observed processes with the growing contribution of agriculture to the total volume of greenhouse gases and consider it necessary to take measures to slow down the growth rates of individual sectors of agriculture. To assess the feasibility of such a decision and its possible impact on the achievement of SDG 2, let us turn to the trends in global agricultural production.

2.2 Key trends determining the dynamics of global agricultural production

The market is sensitive to changes occurring in the economy: in response to the growth of demand, supply also grows. In the last decade, the growth of the Earth's population, the improvement of agricultural production technologies, storage and processing of agricultural products, were accompanied by an expansion of the sown areas of agricultural crops, an increase in the number of farm animals against the background of increased intensity and efficiency of global agricultural production.

For the near future, experts highlight the following trends that determine the situation in global agricultural production:

- increasing intensity of interaction between participants in the global agricultural market: in 2010–2021, the ratio between global exports and global production of agricultural products increased by 6%;
- digitalisation of the agricultural production sector (McFadden J., Casalini F., Griffin T., Anton J., 2022);
- development of biotechnology and expansion of deep processing of agricultural raw materials;
- increasing impact of global climate change on the efficiency of agricultural production and the introduction of response mechanisms for regulating agricultural development aimed at preventing climate change, adapting to it, as well as mechanisms for regulating agricultural markets;
- gradual slowdown in the growth of global demand for food, a decrease in the growth rate of agricultural production and other trends associated with increased attention from the leadership of various countries to the problem of food security.

At the same time, the shocks of the past three years: the coronavirus pandemic, disruptions in the logistics infrastructure of the global agri-food market, the introduction of sanctions restrictions and much more had virtually no effect on the dynamics of global consumption, production and export of agricultural products. As can be seen from Figure 1, only the production of pig meat in physical equivalent showed a slight decline in 2019. In general, both global consumption and global export of all types of meat show a positive trend. The exception was 2019 for global consumption of all types of meat, which can be explained by the temporary impact of the pandemic shock and restrictions. To a greater extent, the impact of external shocks could be observed in large-scale fluctuations in prices for various types of these products (Carleton, 2022).

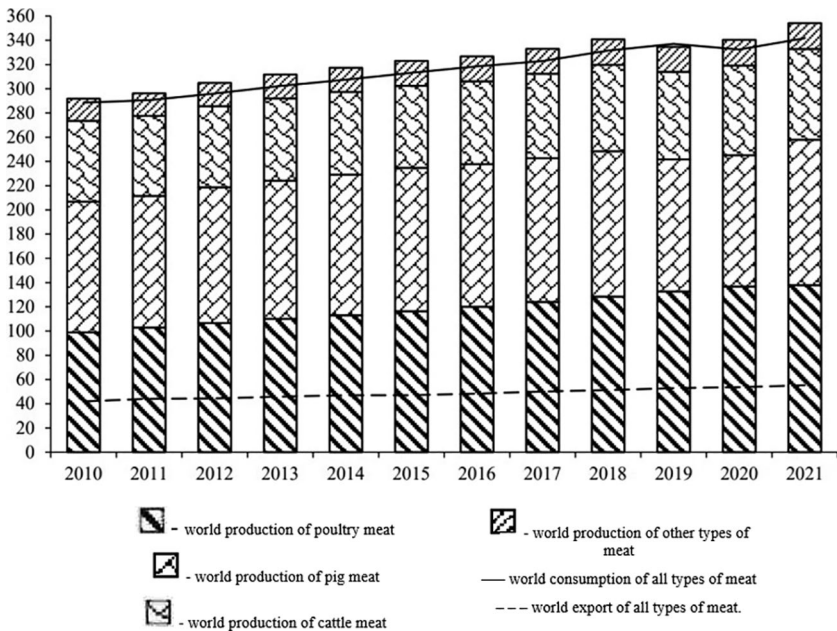


Figure 1: World production, consumption and export of meat, million tons in slaughter weight.

Source: FAOSTAT (2024)

The transformation processes occurring in response to the changing situation in the global agricultural market have both positive and negative consequences.

One of the positive trends in the development of the global agro-industrial market is the expansion of agricultural crop areas (+1.1% per year on average for 2010–2021) and an increase in the number of farm animals. But it has negative consequences for climate change, in some cases associated with the increased contribution of agriculture, as an anthropogenic source of atmospheric pollution, to the total volume of greenhouse gases. Thus, achieving SDG 13 (Climate Action) conflicts with achieving SDG 2 (End hunger, achieve food security, improve nutrition and promote sustainable agricultural development).

3 Results: Opportunities and threats of agriculture in the context of quality of life

The agricultural sector, due to its deep and inseparable connection with natural ecosystems, is one of the areas of the economy most susceptible to the negative effects of climate change. Thus, as a result of the cumulative impact of droughts, overgrazing of farm animals and locust invasions, in some regions in some years there is a complete destruction of vegetation (Shinkarenko et al., 2020). Such situations pose a threat not only to the sustainable development of agriculture, but also have a negative impact on the quality of life of the population.

In countries with a high share of agriculture in GDP, a decrease in crop yields causes an increase in poverty, which has a negative impact on the health of the population (Lin et al., 2023). Thus, in the countries of Central Asia, where the share of the population engaged in agriculture is relatively large, climate change leads not only to a decrease in the productivity of agricultural crops, but also to losses of part of the harvest due to limited opportunities for the use of agricultural chemicals due to limited subsidies and investment in this area. This does not allow the rural population to receive the usual level of income, increasing the level of poverty.

In the Russian Federation, the indigenous peoples of the North, Siberia and the Far East are a population group that is particularly vulnerable to climate change (Pasalic and Pavic, 2021). For them, their way of life and traditional forms of economic activity: reindeer herding, fishing, hunting, agriculture, directly depend on natural and climatic conditions. Significant warming associated with climate change in the latitudes of

historical settlement of these peoples poses serious risks to maintaining their usual way of life.

As shown by the results of surveys conducted by scientists during scientific expeditions, there are manifestations of climate change that negatively affect the life of indigenous peoples. Thus, due to more frequent thaws and winds in the winter, crust and ice crust form on the soil in the tundra, preventing reindeer from getting reindeer moss. Feeding reindeer with other types of food causes them to get sick (Karimbaeva et al., 2022). Changes in the timing of snow cover formation and ice formation, as well as the laying of pipelines, change the usual migration routes of reindeer. Rising seasonal temperatures and the laying of pipelines under river beds lead to a decrease in the number and a change in the species composition of fish, interfere with their passage to spawning grounds, including due to the noise effect from pipelines (Dengov et al., 2020). The number of commercial marine mammals is decreasing. On land, the timing and routes of seasonal migration of commercial animals are also changing.

Due to the melting of permafrost and the construction of dirt roads, insects and rodents previously uncommon in the traditional settlements of indigenous peoples are penetrating there, including carriers of infectious diseases. In the summer, the number of blood-sucking insects increases midges and gnats.

Changes in the habitats of pathogens, as well as contamination of water due to damage to water supply and sewerage systems and other sanitary facilities, lead to an increase in the incidence of infectious diseases (Grullon et al., 2019).

In addition, climate change increases the cumulative effect of a number of other negative impacts, including anthropogenic ones, especially air pollution in Arctic cities.

Climate change, together with the environmental consequences it causes, has a negative impact on the life and health of residents of Arctic cities and on the indigenous population of the Arctic zone of the Russian Federation (Revich and Terentyev, 2015). Maladaptation to climate change (seasonal temperatures, air humidity) causes an exacerbation of cardiovascular and respiratory diseases in the local population. As a result of heat and cold waves, climate change causes additional mortality.

We have provided only a few striking examples of the direct impact of climate change on agriculture and the quality of life of the population.

To overcome this threat, a number of measures have been taken at the state and regional levels of governance, as well as by individual companies, to protect the population and territories within the framework of adaptation to climate change, which takes into account the characteristics of natural and climatic conditions, the socio-economic situation and resource availability of specific territories (Antonova and Pchelintsev, 2023).

However, the question is increasingly being raised about whether it is enough to adhere to an adaptation strategy in order to counter climate change and ensure sustainable development in the long term. Moreover, experts and scientists suggest rethinking the impact of agriculture on climate change and paying more attention to the industry's contribution to the total volume of greenhouse gases.

According to the latest data, if the livestock sector continues to operate without the implementation of low-carbon practices, emissions from the agricultural sector will amount to 49% of all greenhouse gas emissions in the world by 2030 (Bajgar et al., 2023). Moreover, of the two leading sectors of agriculture: crop production and livestock farming, a significant share of the total amount of this volume is allocated to methane, 95% of which comes from the livestock sector (Sutton et al., 2024).

The conclusion about the need to reduce agricultural production to reduce greenhouse gas emissions, which suggests itself in the current situation, in our opinion, does not correspond to the key trends that determine the dynamics of global agricultural production. Given the nature of the key trends analysed by us above, in order to provide humanity with the necessary food products by 2050, it is necessary to increase global agricultural production by 70%. The identified problem is of great importance both for achieving long-term sustainability and for the quality of life of the population.

In our opinion, at this stage of scientific and technological development, it is necessary to develop all aspects of global agriculture, and one of the keys to success is innovation. In addition, the reduction of greenhouse gas emissions itself may be virtually impossible without a green transition – making serious changes in consumption and production patterns (Coase, 1937). Measures taken towards sustainable development of agriculture have their results and in practice are manifested in the technological transformation of the sector (Gagulina, 2023).

Great opportunities are opened up by the development and application of advanced technologies of the knowledge economy (Figure 2).

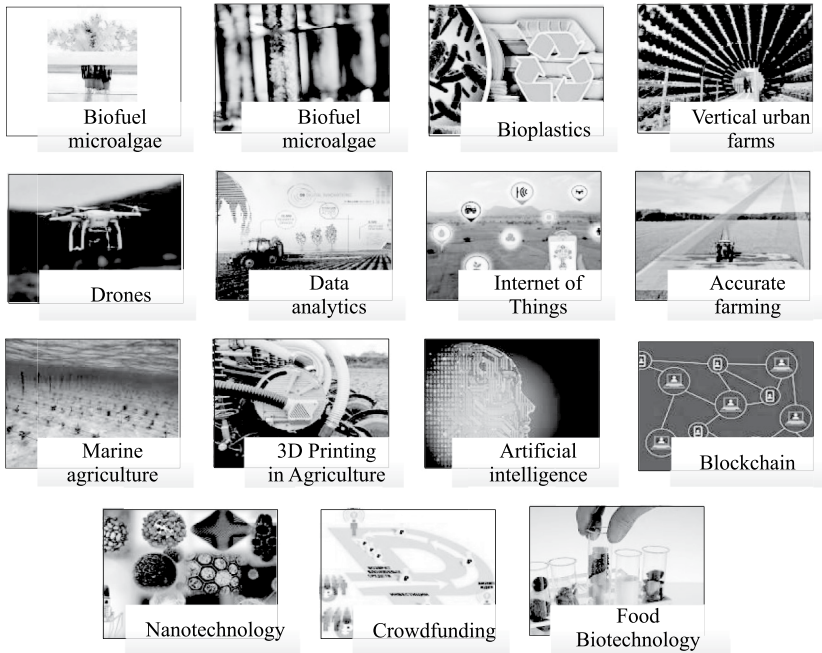


Figure 2: Technologies for the future sustainable development of agriculture.

Source: own elaboration

The lower half of Figure 2 shows the technologies of the future, and the upper half shows technologies that have already found at least limited application. For example, crowdfunding can be used to attract investment in agriculture as an effective tool for raising funds for any projects, from creative ones to complex technological products (Simachev et al., 2021). A significant role in the development of the agricultural sector is given to agricultural biotechnologies, which are structurally part of the industries that form the knowledge economy. The feasibility of turning to high-tech production for the sustainable development of agriculture is confirmed by the current technological restructuring of developed countries, based on the latest digital solutions,

including their applications to production and transport, as well as solutions in the field of energy, materials, biotechnology and medicine.

4 Discussion

There are less than ten years left to achieve the sustainable development goals. The data we have received and analysed already indicate the existence of problems that do not allow us to say with certainty that the goals will be achieved within the established time frame. The worsening situation in the global economy in the area of SDGs forces us to reconsider approaches to their achievement and set new tasks.

A joint analysis of some aspects of achieving SDG 2 (End hunger, ensure food security, improve nutrition and promote sustainable agriculture) and SDG 13 (Combat climate change) showed that some experts believe it is necessary to pay closer attention to combating greenhouse gas emissions from agriculture. First of all, this concerns methane, which accompanies the development of livestock farming.

At the same time, an analysis of the global agricultural market showed that the demand for it is constantly growing and there is a positive trend in agricultural production. It can be assumed that in the context of constantly growing demand for livestock products, the introduction of restrictions associated with the production of livestock products will further exacerbate the difficulties in achieving SDG 2.

5 Conclusions

It is possible to preserve opportunities for improving the quality of life in the context of global climate change and growing demand for agricultural products if we take advantage of the benefits of globalisation. One of these benefits is the comprehensive application and dissemination of advanced knowledge economy technologies in agricultural sectors. Hydroponics, microalgae and biofuels, bioplastics, vertical urban farms, the use of drones and data analytics, the Internet of Things and precision farming already offer wide opportunities in the field of practical application. Future technologies include marine farming, 3D printing in agriculture, the use of artificial intelligence, blockchain, the development of nanotechnology, crowdfunding and food biotechnology.

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