ANNALS OF THE POLISH ASSOCIATION
OF AGRICULTURAL AND AGRIBUSINESS ECONOMISTS

ROCZNIKI NAUKOWE
STOWARZYSZENIA EKONOMISTÓW ROLNICTWA I AGROBIZNESU

Received: 30.12.2024
Acceptance: 25.04.2025
Published: 25.06.2025

JEL codes: Q15, Q10

Annals PAAAE • 2025 • Vol. XXVII • No. (2)

DOI: 10.5604/01.3001.0055.1480

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THE FUNCTIONING OF CROP-PRODUCING FARMS IN THE CONTEXT OF CLIMATE CHANGE IN THE WARMIŃSKO-MAZURSKIE VOIVODESHIP

Keywords: farm, crop production, climate change, European Green Deal, sustainable development

ABSTRACT. There is a complex feedback relationship between agriculture and climate change. On the one hand, climate change significantly affects the conditiof agricultural production. On the other hand, agriculture imposes a substantial burden on the natural environment. Therefore, it is essential for farmers to undertake actions that make agricultural practices both more environmentally sustainable and more resilient to climate change. The aim of this study was to identify the challenges faced by crop-producing farms and the adaptive measures implemented in response to climate change. The research employed a literature review and a survey method. The survey was conducted in the second quarter of 2024 and included responses from 112 farm owners in the Warmińsko-Mazurskie Voivodeship who specialize in crop production. The findings indicate that Polish farmers primarily recognize economic challenges arising from the increasingly volatile operating environment. The most frequently cited concerns were rising production costs (82.1%) and unstable sales prices (79.5%). The third most commonly mentioned challenge was environmental – drought (78.6%) – which may be directly related to climate change. Farmers – partly due to increased awareness of climate change and partly in response to legal regulations – have adopted various environmentally friendly practices. These include the use of modern agricultural machinery and equipment (67.9%), precision dosing systems (25.0%), and navigation technologies (19.6%). Furthermore, many farms (59.8%) utilized energy derived from renewable sources.

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INTRODUCTION

For centuries, the possibilities for human settlement have been determined by the climate and the consequences of climate change have been reflected in the economy (Mirkowska, 2009). Climate changes, observed since the mid-20th century, have definitely accelerated and are considered to be influenced primarily by anthropogenic factors, i.e. related to human activities. The consequences of climate changes are already being felt in many parts of the world and are affecting various human activities. Agriculture is particularly dependent on weather and climatic conditions (Trinh, Rañola, Camacho, Simelton, 2018) and climate change may negatively affect agricultural productivity. The risk arises from rainfall and temperature variability, which can lead to extreme climatic events such as floods and droughts across the globe.

The current intensive agricultural production and food systems are unsustainable from a natural resource perspective and can lead to land degradation, loss of nutrients and loss of biodiversity, also lead to reduced water quality and water scarcity, contribute to increase emission of greenhouse gasesand air pollution. This is confirmed by the Intergovernmental Panel on Climate Change (IPCC) report 2019, which indicates that high level of greenhouse gas emissions comes from agriculture, forestry and land use (IPCC, 2019).

Taking into consideration the deteriorating state of the natural environment in the European Union (EU) countries, inter alia as a result of intensified climate changes, the European Commission in December 2019 prepared a Communication on a European Green Deal (EGD), aimed at initiating international action to achieve economic goals for a much stronger respect for pro-environmental and pro-climate practices (Wrzaszcz, Prandecki, 2020). The European Green Deal is a strategy for growth that aims at building a modern, resource-efficient and competitive economy, with the target of achieving zero net greenhouse gas emissions in 2050 and economic growth that will be taking into account the optimal use of natural resources (Adamowicz, 2021).

It is expected that EGD will not only meet the challenges of climate change and environmental degradation, but will also contribute to improving the quality of life for current and future generations. According to Wiśniewski and Marks-Bielska (2022), the implementation of EGD brings together both opportunities and threats to the development of the Polish countryside and agriculture. Opportunities include the mobilisation of funds from the EU budget for sustainable investments, supporting climate objectives in rural areas, reducing the carbon footprint of agriculture and enabling the development of sustainable economic activities, as well as creation of green jobs for rural residents. Threats are primarily related to concerns about price increase and limited availability of food products (Gradziuk et al., 2021).

Within the EGD, one of the key actions with regard to the agricultural sector is the "EU Farm to Fork" strategy. In the current institutional setting, agricultural production

will therefore be undergoing changes. The CAP, as implemented in the EU countries, is an expression of the awareness of the threats presented by the climate and environmental crisis and the growing demand for food, as a consequence of the increasing human population, as well as the social problems identified in the EU's rural areas. The current CAP, which separates support from production, does not favour any particular farming method. However, between 2023 and 2027, direct payments have been linked to the fulfilment of certain standards and requirements (so-called conditionality). This means combining existing greening and cross-compliance requirements with basic management requirements and good agricultural and environmental standards. In view of the above, farmers receiving support must apply certain sustainable farming practices that optimise production processes and their impact on the environment. The European Union also supports alternative production methods, such as organic farming, carbon farming and animal welfare, which promote sustainability (Babuchowska, 2023).

The transition to a more sustainable agriculture not only depends on the transformation of the entire production process, but also – to a significant extent – on attitudes towards and education about healthy and sustainable nutrition of the population (Boix-Fayos, de Vente, 2023). As evidenced by the research of numerous authors (Mertz, Mbow, Reenberg, Diouf, 2009, Arunrat, Wang, Pumijumnong, Sereenonchai, Cai, 2017, Mitter, Larcher, Schönhart, Stöttinger, Schmid, 2019), farmers in many countries around the world, recognise the impact of climate changes on their operations and therefore undertake adaptation activities. The adaptation process undertaken by farmers, also their behaviours and decisions can be determined by psychological, social and economic factors.

The aim of the article was to present the challenges of plant production on farms located in the Warmińsko-Mazurskie Voivodeship, in the context of climate changes and the activities undertaken on farms as a result of these changes. The decision to limit this research to farms specialising in plant production was determined by the great diversity of agricultural production and different strategies for adaptation to climate changes resulting from this diversity.

MATERIAL AND RESEARCH METHODOLOGY

The study used literature review and survey methods. The survey was conducted in farms in the Warmińsko-Mazurskie Voivodeship. In this voivodeship, agriculture is one of the most important sectors of the economy, as evidenced by the fact that in 2022 its share (together with forestry, hunting and fishing) in GDP was 5.7%, while the national average was 2.5%.

The survey was conducted in Q2 2024. The selection of respondents was purposive. It was limited to farms specialising in crop production, which dominates among Polish

farms. According to the General Agricultural Census, 56% of farms are engaged in plant production. In order to gather research material, the traditional survey method was compiled with the CAWI method. In this way, it was possible to reach a larger group of respondents. The author's survey questionnaire contained a structured set of questions, which were divided into 4 groups. The first concerned the characteristics of the agricultural activity carried out, the next focused on the challenges posed by climate change and its consequences for farms, the third part concerned knowledge and use of modern agricultural production technologies, and the last on the use of CAP funds. The survey questionnaire was distributed directly to 358 farmers and an electronic version was also requested on social media and in farmers' forums. In total, responses were received from 112 respondents. Frequency analysis and tables were used to interpret the survey results. The data collected is presented in descriptive and graphical form. The lack of representativeness of the research sample, due to its size and small area, covering one province, do not allow the conclusions to be generalised. This premise also contributed to the discussion of the results of other authors' research.

Respondents participating in the survey had many years of farm experience. Almost 25% of the surveyed farmers had managed their farm for 6-10 years, for 19.6% it was 11-15 years, 17.9% – 21-30 years, 10.7% – 16-20 years. The surveyed group also included farmers who had been managing the farm for more than 30 years, their share in the structure was 13.4% and those who had been involved with the farm for 5 years or less (14.3%). The majority of respondents (69.6%) had an agricultural education (university, secondary or vocational). The share of those with vocational education and at least five years of work experience was 9.8%, and those with higher education but other than agricultural education and at least three years of work experience in agriculture was 7.1%. Those with non-agricultural secondary education and at least three years of work experience in agriculture accounted for 6.3%. Those with non-agricultural tertiary education and postgraduate studies in agriculture-related fields were less than 4.0%. The group of people who had only completed an agricultural course and the group of respondents with primary education and at least five years of work experience in agriculture were the least numerous, their share being 1.8% each, respectively.

An important factor that determines the agricultural production carried out on a farm is the area of land owned. Among the farms participating in the survey, almost a third had between 30.1 and 50.0 ha of land. The share of farms with 20.1-30.0 ha and 50.1-100.0 ha was 18.8% each, and slightly less, 14.3%, were farms with more than 100 ha. In contrast, 11.6% of the surveyed group had a farm between 10.1 and 20.0 ha, and 6.3% of respondents had farms of 10.0 ha and less.

According to the research design, the main direction of production carried out on the farms was crop production, which is the primary production in agriculture, and its task is the efficient use of farmland on the farm (Niewęgłowski, Gugala, Szczygielska, 2023).

From the indications of the respondents, it appeared that the farms mainly grew cereals and corn (73.2%). A relatively high percentage of respondents also indicated that rapeseed was grown – it was 35.7%. Sugar beet (11.6%) and broad bean crops (9.8%) appeared much less frequently among the responses. The share of farms that grew potatoes was only 6.3%. The crop production carried out on farms did not exclude undertaking other activities to a lesser extent. The survey showed that almost 20% of respondents kept dairy cows, and a few (2.40%) also kept pigs.

RESULTS OF RESEARCH

Polish farmers conduct their business in a dynamically changing environment. Recent years in particular have been characterized by numerous and unexpected crises. One of the first was the COVID-19 pandemic, which reduced activity in all areas of the economy due to the lockdowns put in place. This was followed by the outbreak of the Russian-Ukrainian conflict, as a result of which the price of agricultural crops on the market was shaken. In parallel, these phenomena were accompanied by changing regulations resulting from, among other things, EU's climate policy, including the provisions of the National Strategic Plan for the CAP for 2023-2027. All this makes it difficult to carry out agricultural production.

Although there are numerous challenges that accompany farming, respondents' perceptions of them varied. As can be seen from the information collected (Figure 1), most indications of future challenges facing farmers were economic in nature. As many as 82.1% of respondents indicated that they were concerned about rising production costs, which may be due to past experience of rising prices of mineral fertilizers, fuels, agricultural equipment, but also labor costs. According to Sadowski's (2022) study, the steep increase in fertilizer and fuel prices in 2022 was particularly severe for Polish farmers. It is estimated that for crop production, the cost of mineral fertilizers and protection products is about 23% of its value. The second major challenge, indicated by 79.5% of respondents, was unstable prices for sold agricultural products. Grain prices in Poland are derived from global trends. While prices were rising in 2005-2022, in 2023 and 2024 oversupply, resulting from favorable weather conditions, caused prices to fall, especially for wheat (Kalinowska, Bórawski, 2024). Difficult-to-predict price changes negatively affect farmers' sense of financial security, cause problems in estimating future income, and this makes it difficult to plan and invest in farm development. As Harkness and co-authors (2021) point out, the stability of agricultural income in is as important an issue as its amount. The third challenge most frequently cited by surveyed farmers was environmental in nature and related to the occurrence of drought (78.6% of indications). Drought, along with extreme weather events, is one of the factors causing crop losses.

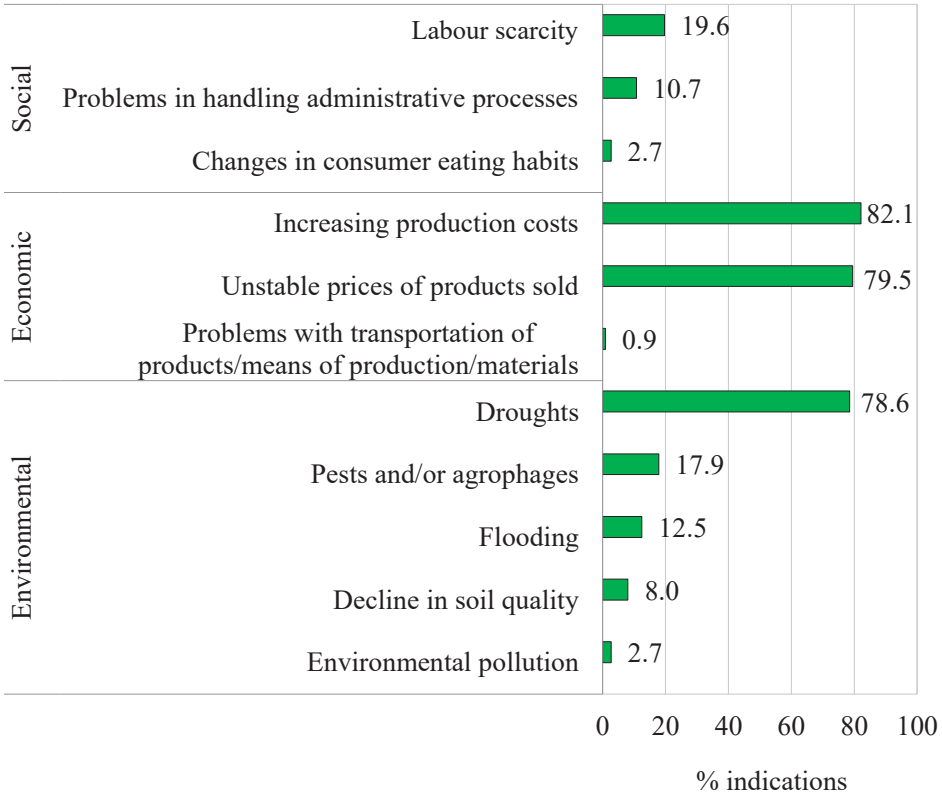

Figure 1. Farm challenges for the coming years (respondents could point to more than 1 answer)
Source: own research (n = 112)

The main reason for the appearance of drought is the increase in air temperature during the growing season and the occurrence of rain-free periods or periods characterized by lower than average precipitation (Doroszewski et al., 2012). This means that a significant area of Poland has a dodgy water balance during the growing season. The frequency of droughts during critical periods for crops has increased significantly, and in certain areas of Poland is often categorized as a natural disaster. Other challenges of an environmental nature included the emergence of pests (17.9%) and flooding (12.5%).

Nearly 20% of participating farmers also considered labor shortages in the category of challenges facing agriculture in the coming years. Limited labor resources in agriculture are observed not only in Poland, but also in other EU countries. The problem is due, among other things, to low interest, especially among young people, in agricultural work. As a result, there is a problem with succession in agriculture and an increase in the age

of those in charge of farms. This is confirmed by a study by Czekaj (2016), which shows that the owners of many Polish farms have problems passing them on to their successors. As a result, the share of farm managers under the age of 40 is declining.

In the face of the identified challenges, but also in connection with the EU climate policy, new solutions and pro-environmental measures were implemented on the surveyed farms. As can be seen from the information presented in Figure 2, the participating farmers most often introduced modern agricultural machinery to their farms (67.9% of indications). The survey results obtained are confirmed by the literature. A study by Jezierska-Thöle, Kluby and Weitz (2016) shows that farmers most often purchase agricultural machinery and equipment when introducing innovations to their farms. The increasing emphasis on environmental protection is forcing manufacturers of agricultural machinery to use solutions in new models that will mitigate adverse effects on the natural environment. These solutions include reducing the carbon footprint of machinery, as well as looking for new solutions for obtaining energy, such as electricity, hydrogen or methane.

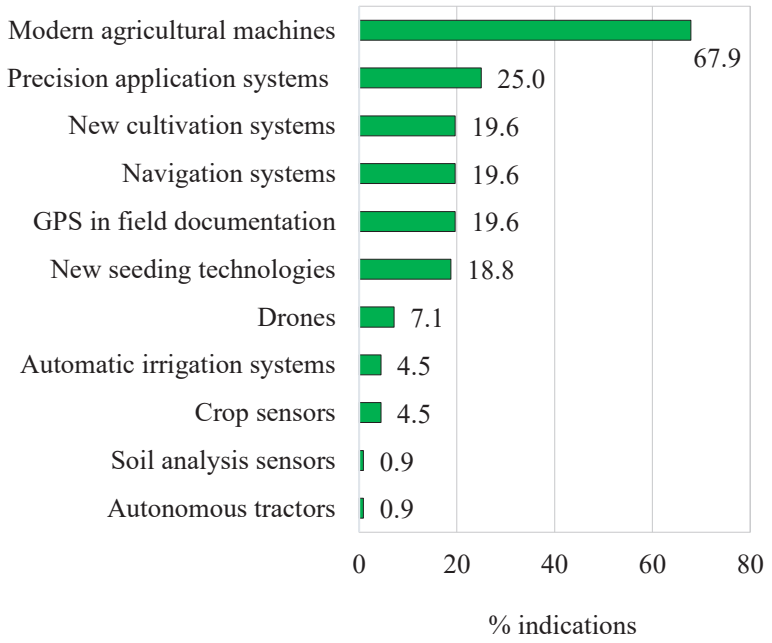

Figure 2. Pro-environmental solutions employed on surveyed farms (respondents could point to more than 1 answer)

Source: own research (n = 112)

One in four respondents indicated implementing a precision application system on the farm. This means that many farmers, balancing between maximizing yields and minimizing damage to the ecosystem, were increasingly opting for precision crop management. This was followed by nearly 20% of respondents using GPS systems for field documentation, with a similar share of farmers using new seeding technologies and navigation systems.

Field mapping makes it possible to precisely adjust agronomic treatments to the conditions of specific areas of the field. Precision agriculture is a modern farm management strategy aimed at bridging spatial and temporal variation using data and modern technologies (Karunathilake, Le, Heo, Chung, Mansoor, 2023). As Klepacki (2020) points out, the use of precision agriculture allows for the efficient and precise use of agricultural inputs, including a reduction in the use of chemicals, and can therefore bring significant economic and environmental benefits. Slightly more than 7% of farmers surveyed used drones on the farm. Among other things, these devices are equipped with photo-optical sensors and multispectral cameras, so they can collect various information, which is then analyzed. By using drones, it is possible to detect the invasion of agrophages, identify the largest weed clusters in the field, determine the abundance of water, minerals, nutrients and organic matter in the soil (Wojcik, Karpowicz, 2023). Adaptation to climate change, as well as a pro-environmental approach in farm management, is evidenced by the fact that 77.7% of respondents had commissioned laboratory tests for the farm, including soil acidity and microbiological testing. Within the structure of the farmers surveyed, there was a slightly smaller share of respondents (60.7%) who had a fertilizer plan on the farm.

The use of modern, environmentally friendly agricultural production solutions brings numerous benefits. This fact was recognized by more than 91% of respondents. The benefits mainly manifested themselves in reduced energy (52.9% of indications) and fuel consumption (47.1% of indications), as well as fertilizers (23.5% of indications). As many as 69.6% of respondents also observed an improvement in soil quality, and 21.6% of respondents said it saves their working time. According to Arvanitis and Simeonaki (2020), innovative smart technologies that provide solutions such as robotic and automated systems, artificial intelligence and machine learning, for example, allow for sustainable agricultural production.

In recent years, renewable energy sources (RES) have become increasingly important in the generation of electricity and heat, including on farms. The main reason for this is seen as the possibility of reducing environmental pollution. The use of renewable sources yields "clean" energy, the demand for which is growing all the time. Renewable sources are considered inexhaustible (wind, sun, water fall) or renewable in a relatively short time (biomass). Another reason why farmers choose to invest in RES is economic. Farmers invest in RES both because of the opportunity to reduce operating costs and to diversify their sources of income. Importantly, this income becomes more predictable than solely from agricultural production (Wiśniewski, 2014). Among other arguments attesting to the

advantages of using alternative energy sources on farms is the desire for at least partial independence from future energy price increases, the possibility of obtaining guaranteed income for a fixed period, or contributing to the development of RES (Pahl, Radziłowicz, 2023).

Although the level of use of these sources on Polish farms is not high, of the farms surveyed, almost 60% used alternative energy sources. As the information summarized in Figure 3 shows, this was mainly solar energy (57.1% of indications). Few respondents (12.5%) indicated having heat pumps. Even smaller was the share of households that used biofuels (4.5% of indications). Rare in the surveyed group was the use of biogas, this energy source was indicated by only 2 farmers (0.9%).

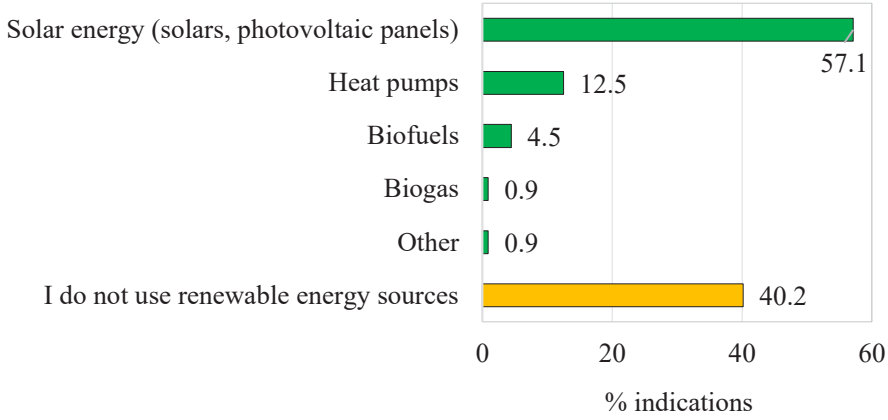

Figure 3. Use of renewable energy sources on surveyed farms (respondents could point to more than 1 answer)

Source: own research (n = 112)

The results obtained correspond with the results of a study conducted by Przygodzka and co-authors (2023), which shows that on farms in Eastern Poland, the source of energy on farms with RES was solar energy, and heat pumps, biomass boilers and wind turbines occurred on a small number of farms.

As farms can receive payments under ecoschemes for carrying out activities that benefit the environment, climate and animals, this thread was also analyzed. Ecoschemes are a new type of direct payment, mandatory for each EU member state, but optional for farmers themselves. The task of ecoschemes is to protect soils, water, climate and biodiversity in agriculture. With the implementation of new measures, soils are likely to become more fertile and resistant to other factors. As stressed, these are not mandatory payments for

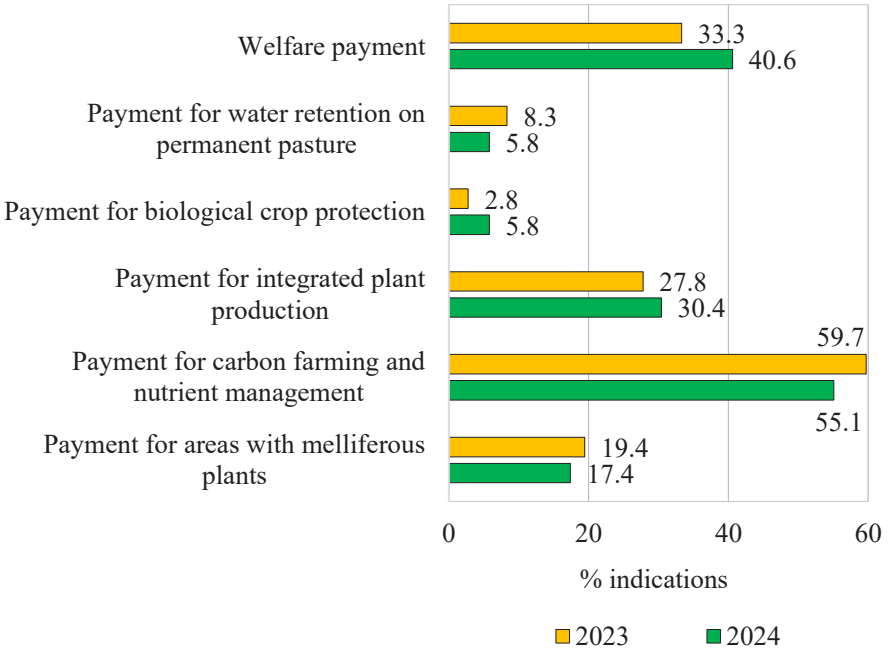

Figure 4. Subsidies applied for on surveyed farms in 2024 and the year before the survey (respondents could point to more than 1 answer)

Source: own research (n_{2023} = 72, n_{2024} = 69)

every farmer, so among the 112 farms participating in the survey, 64.3% used ecoschemes in 2023, and 62% used ecoschemes in 2024.

As can be seen from the information presented in Figure 4, in both 2023 and 2024 the surveyed farmers most often benefited from carbon farming and nutrient management subsidies, this was 59.7 and 55.1% of the group using ecoschemes, respectively. The results of a study by Styburski, Kozera-Kowalska and Uglis (2023) showed that in 2023, farmers from the Warmińsko-Mazurskie Voivodeship (along with Podlaskie, Kujawsko-Pomorskie and Pomorskie voivodeships) were among the group most interested in the new form of direct payments. A relatively high percentage of respondents also applied for a welfare payment (33.3% in 2023, 40.6% in 2024, respectively) and a subsidy for integrated plant production (27.8% in 2023, 30.4% in 2024, respectively). Relatively few respondents applied for a subsidy for water retention on permanent grassland and a subsidy for biological crop protection.

CONCLUSIONS

In response to the climate crisis and other challenges related to the state of the environment at the EU level, an EEZ has been developed. Its leading goal is to make Europe a climate-neutral continent by 2050. To realize this strategy, it is necessary to implement in all areas measures that contribute to sustainable development. This issue also applies to food production, and agriculture, as the first link in this chain, is an important area for implementing the necessary changes.

A research conducted among farmers in the Warmińsko-Mazurskie Voivodeship specializing in crop production shows that it is not environmental issues, but economic issues that are the biggest challenge for this 112-unit group. Nonetheless, these farmers are undertaking numerous activities aimed at adapting to both climate change and regulations resulting from the EEZ. In order to reduce the negative impact on the environment, the surveyed farms are using modern agricultural machinery that uses less fuel and emits less pollution into the atmosphere, modern farming systems, GPS and drones. In addition, more and more farm operators in the Warmińsko-Mazurskie Voivodeship are using RES (mainly solar energy). Some of the farmers surveyed, in an effort to make their production sustainable, are taking advantage of the support offered under the new direct payments known as ecoschemes.

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FUNKCJONOWANIE GOSPODARSTW ROLNYCH UKIERUNKOWANYCH NA PRODUKCJĘ ROŚLINNĄ W WOJEWÓDZTWIE WARMIŃSKO-MAZURSKIM W OBLICZU ZMIAN KLIMATYCZNYCH

Słowa kluczowe: gospodarstwo rolne, produkcja roślinna, zmiany klimatyczne, Europejski Zielony Ład, zrównoważony rozwój

ABSTRAKT. Między rolnictwem i zmianami klimatu istnieje sprzężenie zwrotne. Z jednej strony, zmieniający się klimat ma duży wpływ na warunki prowadzenia produkcji rolnej, a z drugiej, produkcja rolna mocno obciąża środowisko naturalne. W związku z tym ważne jest, aby rolnicy podejmowali w gospodarstwach działania, które pozwolą uczynić produkcję rolną bardziej przyjazną środowisku, a jednocześnie bardziej odporną na zmiany klimatu. Celem artykułu była identyfikacja wyzwań, które towarzyszą prowadzeniu produkcji roślinnej w gospodarstwach rolnych w obliczu zmian klimatycznych, a także działań, które są podejmowane w gospodarstwach w odpowiedzi na te zmiany. Zastosowano przegląd literatury przedmiotu oraz metodę ankietową. Ankietę przeprowadzono w II kwartale 2024 roku. Wypełniony kwestionariusz ankiety pozyskano od 112 właścicieli gospodarstwach rolnych z województwa warmińsko-mazurskiego, specjalizujących się w produkcji roślinnej. Stwierdzono, że polscy rolnicy identyfikując wyzwania, którym muszą sprostać w najbliższych latach, w pierwszej kolejności dostrzegają kwestie ekonomiczne, wynikające z funkcjonowania w bardzo zmiennym otoczeniu. Najczęściej wymieniano rosnące koszty produkcji (82,1% odpowiedzi) i niestabilne ceny zbytu (79,5%). Dopiero susza (78,6%), wymieniana jako trzecie w kolejności wyzwanie, miała charakter środowiskowy i może być łączona ze zmianami klimatycznymi. Rolnicy, po części świadomi zmian klimatycznych, a po części zmuszeni obowiązującymi regulacjami prawnymi, stosowali w gospodarstwach rozwiązania ograniczające negatywny wpływ rolnictwa na środowisko. Do takich rozwiązań należało stosowanie m.in. nowoczesnych maszyn rolniczych (67,9% wskazań), systemów precyzyjnego dawkowania (25,0%) i systemów nawigacyjnych (19,6%). Ponadto w wielu gospodarstwach (59,8%) korzystano z energii pozyskiwanej ze źródeł odnawialnych.

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Proposed citation of the article:
Marks-Bielska, R., Babuchowska, K. (2025). The functioning of crop-producing farms in the context of climate change in the Warmińsko-Mazurskie Voivodeship. *Annals of the Polish Association of Agricultural and Agribusiness Economists*, *27* (1), 142-155.