INSTITUTE OF AGRICULTURAL
AND FOOD ECONOMICS
NATIONAL RESEARCH INSTITUTE

MULTI-ANNUAL PROGRAMME 2015 - 2019

From the research on socially-sustainable agriculture (48)

84.1

MONOGRAPHS OF MULTI-ANNUAL PROGRAMME

WARSAW 2018

**From the research
on socially-sustainable
agriculture
(48)**

INSTITUTE OF AGRICULTURAL
AND FOOD ECONOMICS
NATIONAL RESEARCH INSTITUTE

From the research on socially-sustainable agriculture (48)

Edited by
dr hab. Mariola Kwasek, prof. IERiGŻ-PIB
prof. dr hab. Józef Stanisław Zegar

Authors:
dr hab. Mariola Kwasek, prof. IERiGŻ-PIB
dr hab. Mariusz Maciejczak
dr Wioletta Wrzaszcz
prof. dr hab. Józef Stanisław Zegar

MULTI-ANNUAL PROGRAMME 2015 - 2019

THE POLISH AND THE EU AGRICULTURES 2020+
CHALLENGES, CHANCES, THREATS, PROPOSALS

Warsaw 2018

Dr hab. Mariusz Maciejczak (ORCID No.: 0000-0002-0630-5628) is the researcher in the Warsaw University of Life Sciences. The other authors: dr hab. Mariola Kwasek, prof. IERiGZ-PIB (ORCID No.: 0000-0002-3691-1733); dr Wioletta Wrzaszcz (ORCID No.: 0000-0003-2485-3713); prof. dr hab. Józef Stanisław Zegar (ORCID No.: 0000-0002-2275-006X) are the researchers of the Institute of Agricultural and Food Economics – National Research Institute.

This publication has been prepared under the Multi-Annual Programme 2015-2019 *The Polish and the EU agricultures 2020+. Challenges, chances, threats, proposals*, within the subject **Dilemmas of the development of sustainable agriculture in Poland**, which involves three research tasks, as follows:

Global and national conditions of the sustainable development of agriculture.

Economic assessment of external effects and public goods in agriculture.

Sustainable agriculture and food security.

Reviewer
dr hab. Arkadiusz Sadowski, Poznań University of Life Sciences

Computer development
mgr inż. Bożena Brzostek-Kasprzak

Proofreader
Katarzyna Mikulska

Translated by
Summa Linguae S.A.

Cover project
Leszek Ślipski

ISBN 978-83-7658-765-3

Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej
– Państwowy Instytut Badawczy
ul. Świętokrzyska 20, 00-002 Warszawa
tel.: (22) 50 54 444
fax: (22) 50 54 636
e-mail: dw@ierigz.waw.pl
http://www.ierigz.waw.pl

Contents

Foreword

The Multi-Annual Programme entitled *The Polish and the EU agricultures 2020+. Challenges, chances, threats, proposals*, established pursuant to the Resolution of the Council of Ministers of 10 February 2015, implemented by the Institute of Agricultural and Food Economics – National Research Institute (IAFE-NRI) in Poland between 2015 and 2019, covers among 8 research topics, the issue of **Dilemmas of the development of sustainable agriculture in Poland**. Within this topic, three research tasks have been distinguished, namely:
(1) Global and national conditions of the sustainable development of agriculture;
(2) Economic assessment of external effects and public goods in agriculture;
(3) Sustainable agriculture and food security.

The results of research on these issues, conducted in 2015-2018, were published in Monographs of the Multi-Annual Programme under the name "From the research on socially-sustainable agriculture" No. 31-49. This monograph (No. 48) contains four chapters relating to the first and the third tasks.

The first chapter **Food systems and sustainable food systems** relates to current issues that ensure food security. It contains the definition of this key concept with its components: food supply chains, food environments and consumer behaviour, as well as the typology of food systems. This chapter refers to the current European Union and United Nations documents, standing the foundation for conversion of food systems to sustainable food systems and so favourable to the environment and human health. Dr hab. Mariola Kwasek, associate professor at IAFE-NRI, is the author of the first chapter.

The second chapter **Non-industrial sustainable intensification of agriculture** undertakes scientifically and practically important issue, which is reconciling the need to provide food with the need to preserve the values of the agricultural environment. The Author points out that one of the possible ways to solve the key development dilemmas, resulting from the impact of agriculture on the natural environment and errors committed in the current agrosystem management, is to intensify agricultural production not based on industrial means of production, but through relaying on natural agrobiological mechanisms, such as the symbiotic systems called holobionts. Thus, the Author presents an alternative to industrial intensification of agriculture, which is the use of a holistic concept of agroecosystem. Based on the foresight study, the chapter also presents factors determining non-industrial sustainable development of agriculture and the potential impact of such development on achieving the goals of the Agenda for Sustainable Development 2030. Dr hab. Mateusz Maciejczak is the author of the second chapter.

This chapter is a continuation of the paper *Perspectives of agriculture development on the industrial intensification road* prepared by Mariusz Maciejczak, Tadeusz Filipiak and Henryk Runowski in 2017, which was published in *From the research on socially-sustainable agriculture [39]*, ed. J.St. Zegar, Monographs of Multi-Annual Programme, No. 47, IAFE-NRI, Warsaw.

The third chapter **Agriculture production potential and farms' environmental sustainability – regional convergence or divergence?** presents the assessment of agriculture production potential and farms' environmental sustainability changes during Poland's membership in the European Union, taking into consideration the regional aspect. The aim of this chapter was evaluation of regional convergence (divergence) process in the scope of agriculture production potential and environmental sustainability. Central Statistical Office data for 2005, 2007 and 2016 were used to analyse the period of Poland's membership in the European Union. The main research results concerned farms' organizational conditions and development direction in regional perspective. The special attention was dedicated to the relation between farms' production potential and their environmental sustainability. The evaluation of regional convergence (divergence) process allowed to indicate which issues of agricultural production are currently the biggest challenge in the context of the need for environmental protection. Conducted research enables to answer the question, whether agriculture (farms) in voivodeships became similar in terms of environmental pressure. Dr Wioletta Wrzaszcz is the author of the third chapter.

The fourth chapter **Sustainability of family farms by production and economic type in 2005 and 2016** presents changes in the basic characteristics of family farms with distinction of economic and production types and adopted sustainability indicators in the period after Poland's accession to the European Union. The four types of identified farms occupy a different position in agricultural structures (production and economic), they are characterized by multidirectional changes, and their perspectives are fundamentally different – from development to disappearance. The assessment of farm sustainability mainly focuses on environmental order. Nevertheless, the values of selected indicators relating to economic and social order were also determined. Professor dr hab. Józef Stanisław Zegar is the author of the fourth chapter.

CHAPTER I

FOOD SYSTEMS AND SUSTAINABLE FOOD SYSTEMS

The food systems are extremely complex systems with a long supply chain. The food system was defined as follows: *food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes* [HLPE 2014, p. 12]. The organization of the food system reflects social, cultural, political, economic, health and environmental conditions. Food systems can be considered at different scales (from global to local), and even from a household perspective. Multiple food systems co-exist simultaneously within any given country [HLPE 2017, p. 35]. The food system is also associated with specific effects of its functioning in the form of food security (access to food – physical and economic and its use) [Chase and Grubinger 2014].

1. Components of food systems

The literature on the subject distinguishes three components of food systems: (1) *food supply chains*, (2) *food environments* and (3) *consumer behaviour* [HLPE 2017, p. 24].

The steps of the food supply chain include: production, storage and distribution, processing and packaging, retail and markets. Food supply chains can increase the nutritional value of food, by increasing access to macronutrients as well as micronutrients, for instance through biofortification[1], food fortification or improved storage of perishable foods (such as fruits and vegetables), or by reducing, in food products, the levels of substances associated with diet-related non-communicable diseases – NCDs (e.g. trans fat, high levels of sodium). However, the nutritional value of food can also diminish along the food supply chain (e.g. in the case of food losses and contamination).

Food environment refers to the physical, economic, political and socio-cultural context in which consumers engage with the food system to make their

[1] Biofortification means processes or treatments aimed at increasing the content of minerals as well as vitamins and nutrients in order to improve the biological quality of the crop and, consequently, the health status of consumers. The implementation of these plans can be done using agrotechnical or breeding methods using biotechnology tools. Therefore, it is considered that biofortification can be a "paramedical tool" in the hands of scientists and farmers thanks to which they can indirectly influence the health of entire societies [Smoleń 2013].

decisions about acquiring, preparing and consuming food. The food environment consists of:

- "food entry points" or the physical spaces where food is purchased or obtained[2];
- features and infrastructures of the built environment[3], that allow consumers to access these spaces;
- personal determinants of consumer food choices (including income, education, values, skills, etc.);
- surrounding political, social and cultural norms that underlie these interactions [HLPE 2017, p. 28].

The key elements of the food environment that influence consumer food choices, food acceptability and diets are: physical and economic access to food (proximity and affordability), food promotion, advertising and information, and food quality and safety [Caspi et al. 2012, pp. 1172-1187; Hawkes et al. 2015, pp. 2410-2421; Swinburn et al. 2014].

The food environment is gaining recognition as a major determinant of food choices and diet-related outcomes such as obesity [Roberto et al. 2015, pp. 2400-2409; Swinburn et al. 2011, pp. 804-814]. Thus, a promising approach to improving population-level dietary patterns and associated health outcomes is to intervene in the environments in which food purchasing and consumption decisions are made. Food environment researchers acknowledge the complex psychosocial and environmental factors influencing dietary habits, and have investigated various aspects of the food environment in relation to food purchasing and consumption behaviours, and related health outcomes [Mahendra et al. 2017, pp. 367-362].

Consumer behaviours – *activities and actions taken to obtain goods and services to satisfy needs in accordance with the hierarchy of preferences and the general ways of their use* [Żelazna et al. 2002]. According to Andrzej Falkowski and Tadeusz Tyszka [2001], consumer behaviour *includes everything that precedes, it happens during and after the consumer acquires goods and services*.

Consumers, as market participants, undertake activities aimed at satisfying previously selected consumer needs. All choices and decisions are made under specific social, cultural and economic conditions that create the so-called consumer environment. The consumer experiences change in both the near and

[2] Including, for instance: vending machines, small kiosks, bodegas, corner stores, wet markets and supermarkets, restaurant foraging, production for self-consumption, urban gardens, food banks, formal and informal markets, schools, hospital and public canteens [Herforth and Ahmed 2015].

[3] The human-made surroundings and infrastructure that provide the setting for human activity, in which people live and work on a day-to-day basis.

distant surroundings to varying degrees and extent by participating in the production, exchange and consumption process. The environment at every scale creates restrictions for the actions taken by the consumer both on the market and in consumption. The consumer's contacts with the environment have a real and informative dimension [Bombol 2006, p. 164].

The basic consumer typology, developed by a team of sociologists of agriculture and consumption from the University of Wegeningen, points to the following types of motivation and related behaviour of food buyers [Davegos and Hansman 2001, pp. 143-150]:

1. Calculating consumer – the main motive of purchase is the desire to maximize personal profits while reducing costs. First and foremost practical factors such as price and time influence the decisions made. Calculating consumers caused by economic pressure or convenience are a natural basis for long commercial networks and industrial food chains.

2. Traditional consumer – the approach is characterized by a critical attitude towards innovation. The consumer cautiously approaches industrial food, combining health risks and related decreasing quality. His motivations are prosocial, community and connections with others are important factors influencing his involvement in the development of alternative forms of agricultural production. This type of consumer also shows interest in the ideas of social solidarity and concern for the preservation of traditional values and culture.

3. Nonconformist consumer – this approach to food is personalized. Purchases of unique products are meant to distinguish the consumer from people using the mass market. This consumer is looking for exceptional products that are a status symbol.

4. Missionary consumer – his motivations have quasi-political. The choice of a product becomes a manifestation of discord on the nature of modern economy. He is happy to institutionalize activities (e.g. through participation in short networks).

The above-characterized types of food consumers indicate the degree of complexity of consumer choices influenced by numerous material and non-material factors [Goszczyński 2014, p. 129].

Consumers of high-quality food are also not a homogeneous group of consumers [Oosterveer et al. 2007]. They are divided into two groups:

1. Traditional and missionary consumers – they mainly buy organic and traditional food. Among the motivations prevails concern for the natural environment and the willingness to support local communities. They combine a positive assessment of a part of rural tradition with the will of social innovation, such as participation in direct sales systems. They buy high-quality food for

taste and satisfy intangible needs. Both traditional and missionary consumers are willing to enter into social relations, providing a natural background for alternative forms of agricultural organization.

2. Non-conformist consumers – a group of consumers from the middle class. High-quality food is a fashion element for this group. They make purchases on the basis of material premises (element confirming their social status). A separate group are consumers of functional foods in this category. This type of buyers is primarily interested in products indicating a positive effect on the body [Jeżewska-Zychowicz et al. 2009].

The diversity of consumers causes that organic food is gaining more and more supporters, which does not automatically mean the development of new forms of agriculture [Goszczyński 2014, p. 130].

2. Typology of food systems[4]

Food systems around the world are diverse and undergo constant change, which is important for feeding the population. A wide range of food systems and food environments can exist or co-exist at the local, national, regional and global levels. The basic types of food systems, according to the High Level Panel of Experts on Food Security and Nutrition – HLPE) are:

- traditional food systems,
- mixed food systems,
- modern feeding systems.

The typology presented covers both food supply chains and the food environment to identify the strengths and weaknesses of each type of food system, as well as the challenges and opportunities these systems encounter

2.1. Traditional food systems

In traditional food systems, people generally live in rural areas. Nevertheless, dietary diversity there can be low, partly because people rely mainly on locally grown, fished, herded, hunted or gathered foods and often lack appropriate infrastructure to access distant markets. People tend to grow much of their own food and buy food from local daily and weekly wet markets, and from kiosks. These markets primarily sell fresh foods, but may also sell some packaged foods. Foods are often not monitored for quality and safety.

In traditional food systems, consumers rely on minimally processed seasonal foods, collected or produced for self-consumption or sold mainly through informal markets. Food supply chains are often short and local, thus access to

[4] Section 2 was developed based on [HLPE 2017].

perishable foods such as animal source foods (ASF) or certain fruits and vegetables can be limited or seasonal. Food environments are usually limited to one's own production and informal markets that are daily or weekly and may be far from communities.

In these systems many people's diets primarily consist of staple grains such as maize, rice and wheat, and do not contain sufficient amounts of protein and micronutrients. Stunting rates may, therefore, be high, along with the incidence of micronutrient deficiencies. These nutritional outcomes impact people's immune systems and make them more susceptible to infectious diseases, including diarrhoea and upper respiratory infections. Morbidity and mortality are much too high, especially for children under five years of age.

2.2. Mixed food systems

In mixed food systems, food producers rely on both formal and informal markets to sell their crops. Highly-processed and packaged foods are more accessible, physically and economically, while nutrient-rich foods are more expensive. Frequent branding and advertising accompany everyday activities, seen on billboards and in print publications, while food labelling is sometimes provided in markets. Even when food-based dietary guidelines are available, most consumers have little or no access to this information. Food safety and quality standards exist, but may not always be followed by producers.

In mixed food systems, there is a higher proportion of people living in peri-urban and urban areas and having greater incomes than in traditional food systems. The food environment offers a wider range of "food entry points". People still have access to local wet markets, but also to supermarkets that have a wide variety of processed, packaged and fresh foods all year long. However, access may be limited in low-income areas, and fresh produce and animal source foods are often more expensive than packaged foods. People have access to bodegas or corner stores that are similar to the kiosks in traditional food systems.

People also have more access to prepared meals eaten outside home. Urbanization is accompanied by a rise in street food, which presents another food option in the mixed system. There is a broad spectrum of food quality and safety levels across different food sources. However, emerging regulation results in increased standardization of the quality and safety of foods. More food promotions are seen, especially in supermarkets and at fast food restaurants. The increased availability of packaged foods and food regulation also results in an increase in food labelling and other sources of food information.

In these systems, people tend to have access to diverse foods, leading to sufficient calorie and protein intakes. Both wasting and stunting in children under five are, therefore, rare. Better nutritional status, as well as advances in water provision, sanitation, hygiene and other medical services, lead to lower incidences of, and mortality from, infectious diseases. With the availability and popularity of processed foods, there is increased intake of saturated and trans fats and sugar. There is also increased consumption of animal source foods, which are a source of protein, but also of saturated fat. Some dietary changes result in these systems in an increasing incidence of overweight and obesity and lead to an increased incidence of, and morbidity from, NCDs such as cardiovascular disease and diabetes. While life expectancy increases due to the decrease in infectious diseases, morbidity increases due to the rise in NCDs.

2.3. Modern food systems

Modern food systems are characterized by more diverse food options all year long, and by processing and packaging to extend food's shelf life. These systems include both formal and easily accessible markets in high-income areas and food deserts[5] and food swamps[6] in low-income areas. While the cost of staples is lower relative to animal source foods and perishable foods, specialty foods (e.g. organic, local) are more expensive. Consumers' access to detailed information on food labels, store shelves, and menus and food is highly promoted. Food safety is monitored and enforced, and storage and transport infrastructures (including cold chain) are generally prevalent and reliable.

In modern food systems, a higher proportion of people tend to live in urban areas and have greater incomes and an overwhelming number of food choices. Consumers often live far from where their food is produced. Through technological and infrastructural advances (including distribution and exchange), a wide variety of foods is accessible to consumers all year long. Markets tend to be close to one another, and consumers have options as to where they procure their foods. Supermarkets and wet ("farmers") markets tend to offer more choice, better quality and more specialty items. There are many options for prepared meals eaten outside home, such as fast casual and fine dining restaurants and gourmet food trucks. These tend to use higher-quality ingredients.

As with mixed food systems, there is a wide range in food prices, with fresh produce and animal source foods being more expensive than most packaged foods. However, the relative cost of these commodities compared with

[5] Food deserts – i.e. geographic areas where residents' access to food is restricted or non-existent due to the absence or low density of "food entry points" within a practical travelling distance.

[6] Food swamps – i.e. areas where there is an overabundance of "unhealthy" foods but little access to "healthy" foods.

staples is lower than in the traditional food systems. Produce that is local and organic tends to be more expensive. There are also even more expensive options, including specialty packaged foods and upscale restaurants. Strong regulations and means of implementation enable a strict control of food quality and safety. Even more food promotions and food labelling are seen, and these often have a focus on health or the environment, such as highlighting non-genetically modified (GM), local or organic products.

In modern food systems, the abundance of food, especially highly--processed food, is associated with increased risk of overweight, obesity and NCDs. However, increases in income and education are likely to make people more aware of the relationship between diet, nutrition and health. People in these systems also tend to have increased access to, and quality of, medical care, including the prevention and management of NCDs. This often leads to decreased morbidity and even longer lifespans, despite the presence of these diseases.

The characteristics of food systems: traditional, mixed and modern are presented in Table I.1.

Since 1947, food systems have become more industrial, commercial and global. The substitution of mechanical, chemical and biological technologies for land and labour in agricultural production has unleashed processes of productivity growth, economic development and social transformation that are being felt around the world. Commercialization and specialization in agricultural production, processing and retailing have enhanced efficiency throughout the food system and increased the year-round availability and affordability of a diverse range of foods for most consumers in the world. At the same time, concerns are mounting about the sustainability of current consumption and production patterns, and their implications for nutritional outcomes [FAO 2013, p. 3].

Food systems can be either conventional or alternative. The conventional food system is based on conventional agriculture and industrial food production. Agriculture supplying raw materials in this system is aimed at maximizing the profit achieved thanks to the high efficiency of plants and animals [Matysik-Pejas et al. 2017, p. 144]. This efficiency is achieved on specialized farms, using production technologies based on high consumption of industrial means of production and very low labour inputs [Kuś and Fotyma 1992, pp. 75-86; Kotecki 2015, pp. 7-21]. In these systems, farmers sell only basic commodities and the remaining participants in the agri-food chain, such as processors and distributors, capture added value. As a result of such a system, much less money goes to rural communities [Matysik-Pejas et al. 2017, p. 144].

Table I.1. Characteristics of types of food systems and their food supply chains and food environments

Food supply chains	Food systems		
	traditional	mixed	modern
Production (availability)	Food is mainly produced by smallholders in the area and most of the foods available are local and seasonal.	Food production takes place at both local smallholder farms and larger farms that are farther away. There is greater access to foods outside their typical season.	A wide array of foods is produced at farms ranging from small to industrial in size. Production is global, so foods are available from anywhere and at any time.
Storage and distribution	Lack of adequate roads makes transporting food difficult and slow, leading to food waste. Poor storage facilities and lack of cold storage makes storing food, especially perishables, difficult and leads to food safety concerns and waste.	There are improvements in infrastructure with better roads, storage facilities and increased access to cold storage; however, these are usually not equally accessible, especially for the rural poor.	Modern roads, storage facilities and cold storage make it easy to transport food on long distances and store it safely for long periods of time.
Processing and packaging	Basic processing is available such as drying fruit, milling flour or processing dairy. Little or limited packaging occurs.	Highly-processed Packaged foods emerge and are more accessible. These extend the shelf life of foods.	Many processed Packaged foods are easily available, often cheap and convenient to eat, but sometimes “unhealthy”.
Retail and markets	Low diversity and density of food retail options leads to a heavy reliance on informal kiosks and wet markets.	Greater diversity of both informal and formal bodegas, corner stores and markets. More access to meals eaten outside of home including street food and fast food.	High diversity and density of “food entry points” including all of the options in the other systems as well as larger super and hypermarkets, fast casual food and fine dining restaurants.
Food environments			
Availability and physical access (proximity)	Higher density of local informal markets but longer distances to access formal markets and poor or non-existent roads make travel difficult and long.	There is still a high density of informal markets but there is also a larger number of formal markets. Better road and vehicle access emerges, increasing consumer access to different foods. However, low income consumers often have less access to transportation.	Reliance is on formal markets with locations in close proximity with easy accessibility. Low income areas can often be qualified as food deserts or food swamps.

continued Table I.1

Economic access (affordability)	Food is a large portion of the household budget. Staples tend to be significantly less expensive relative to ASF, which tend to be more expensive.	Food places moderate demands on the household budget. Staples are inexpensive, whereas ASF and perishable foods are expensive. Many highly processed and convenience foods are inexpensive.	Food demands less of the household budget. The price of staples is lower relative to ASF and perishable foods, but the difference is less stark than in the other systems. With more options, specialty items (e.g. organic, locally produced) tend to be more expensive.
Promotion, advertising and information	Very little promotion, with the exception of the efforts of some multi--national companies. Posters, signs in kiosks and on buildings, some billboards. Very little information in terms of labelling and guidelines. Information disseminated largely through public health nutrition education.	Branding and advertisements become more common, including on billboards, in print, radio, television and the Internet. Some information provided, and labels on food products and on the shelves of stores. Dietary guidelines available, but with little or no access in some areas.	High level of food promotion via multiple media channels. Marketing targeted to specific groups (e.g. children). High level of information on labels, shelves in stores and menus. High level of information from public health campaigns.
Food quality and safety	Low control of quality and food safety standards. Little to no cold storage. Less of a demand for quality ingredients.	Quality and food safety controls exist, but are often not adhered to. Food safety adherence is often limited to branded processed packaged foods. Cold storage exists, but is not reliable. Ingredient lists on foods but less emphasis on "natural" or "organic."	Food safety standards are closely adhered to and monitored. Cold storage is prevalent and reliable. Ingredients listed and standardized. Demand for foods and animals grown in certain ways adhering to sustainability and animal welfare practices.

Source: HLPE 2017, p. 37.

Better knowledge of food systems and interaction between food supply chains, food environments and consumer behaviour is key to understanding why and how diets change and affect the nutritional status of people around the world. This understanding is needed to identify ways to intervene and apply a rights-based approach to improve food and nutrition security for all, in particular the most vulnerable.

The conceptual framework and the typology of food systems described illustrate the complexity and variety of problems and challenges facing the current food systems in the world. The food system typology proposed by Food and Agriculture Organization of the United Nations (FAO) is an attempt to consider this complexity when designing paths towards more sustainable food systems that improve food security and human health.

3. Sustainable food systems

Trends and patterns in the production and consumption of food are among the most important factors that affect climate change and the related pressure on the natural environment. In this context, there is an urgent need for food systems to function in a more sustainable way, in a context of scarce resources and in a more responsible manner exploiting natural resources, preserving the ecosystems they are based on. Food systems need to be reformed to improve production and access, and consequently change the current, dominant diet that favors diet-related diseases towards a sustainable diet. These two goals – improving the condition of the natural environment and human health – can be considered simultaneously and are actually best perceived as synergistic. Strengthening local food supply chains and increasing production diversification in an environmentally sustainable way are key to achieving both objectives.

A sustainable food system (SFS) is a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised [HLPE 2014]. The transition to sustainable food systems, therefore, applies to all interrelated activities in the areas of production, processing, transport, storage and consumption of food and its rotation. The role of global trends in consumption as a factor affecting the way of food production and types of food produced is also recognized. Sustainable food systems are an alternative to conventional food production and distribution systems.

Agriculture can change the direction of development through management practices that include ecosystems, water resources, biodiversity and sustainable use of energy and nutrients. In fact, agriculture can be low-emission. The natural techniques used in the cultivation of land can promote the absorption of carbon dioxide, enrich the soil, immunize it for drought and increase productivity [Żywność, zdrowie i zrównoważone rolnictwo…].

More sustainable food production can create new business opportunities and reduce socio-economic burdens. In this way, business can take some of the responsibility off its shoulders. Sustainable agriculture and sustainable production can contribute to a healthy and sustainable diet. It is forecasted that diseases such as cancer and diabetes will cost the world economy 47 trillion US dollars over the next twenty years. In 2010, it was estimated that the direct and indirect global costs of cardiovascular disease were 863 billion US dollars and could rise to 1044 billion US dollars in the next two decades. Such forecasts, together with the increase of knowledge about the state of the natural environment, constitute a huge potential for the future market and trade. This should increase the demand for sustainable consumption patterns [Żywność, zdrowie i zrównoważone rolnictwo…].

According to the demographic forecasts of the United Nations, by 2050 around 9.8 billion people will live in the world. The opportunity to feed such a large population is a great challenge, and at the same time an unprecedented threat to the Planet. Intensive food production systems can not guarantee food security in the long term because they threaten natural resources.

Worldwide, an estimated 2 billion people live primarily on a meat-based diet, while an estimated 4 billion live primarily on a plant-based diet. The American food production system uses about 50% of the total US land area, approximately 80% of the fresh water, and 17% of the fossil energy used in the country. The heavy dependence on fossil energy suggests that the US food system, whether meat-based or plant-based, is not sustainable. According to a study conducted by David Pimentel and Marcia Pimentel [2003, pp. 660S-663S], a diet containing meat products requires more energy, soil and water compared with a lactoovovegetarian (plant-based) diet. In both diets, the daily quantity of calories consumed was kept constant at about 3533 kcal per person. A comparison of the calorie and food consumption of a lactoovovegetarian diet and a meat-based diet is provided in Table I.2. The lactoovovegetarian diet is more sustainable than the average American meat-based diet.

The major threat to future survival and to US natural resources is rapid population growth. The US population of 285 million is projected to double to 570 million in the next 70 years, which will place greater stress on the already limited supply of energy, land, and water resources. These vital resources will have to be divided among ever greater numbers of people [David and Marcia Pimentel 2003, pp. 660S-663S].

Raising awareness that public health benefits are combined with sustainable food production indicates that when changing strategies, both parties, i.e. producers and consumers, should benefit. We are more likely to support the protection of the natural environment if it also affects human health well. The health benefits of reducing meat consumption per capita are just one example of this relationship [Żywność, zdrowie i zrównoważone rolnictwo…].

Table I.2. Per capita food consumption, energy, and protein of foods of a meat-based compared with a lactoovovegetarian diet in the United States

Food	Meat--based diet kg	Energy kcal	Protein g	Lactoovo-vegetarian diet kg	Energy kcal	Protein g
Food grain	114.0	849	24.9	152.0	1132	33.2
Pulses	4.3	40	2.0	7.5	70	4.5
Vegetables	239.0	147	6.6	286.0	155	8.8
Oil crops	6.0	71	3.0	8.0	95	4.0
Fruit	109.0	122	1.4	112.0	122	1.9
Meat	124.0	452	41.1	0.0	0	0.0
Fish	20.3	28	4.7	0.0	0	0.0
Dairy products	256.0	385	22.5	307.1	473	30.0
Eggs	14.5	55	4.2	19.2	73	5.6
Vegetables oils	24.0	548	0.2	25.0	570	0.2
Animal fats	6.7	127	0.1	6.7	127	0.1
Sugar & sweeteners	74.0	686	0.2	74.0	686	0.2
Nuts	3.1	23	0.6	4.0	30	0.8
Total	994.9	3533	111.5	1001.5	3533	89.3

Source: David and Marcia Pimentel 2003.

A new vision of global development outlined in the 2030 Agenda focuses on five major transformational changes referred to as the 5Ps principle (*People*, *Planet*, *Prosperity*, *Peace*, *Partnership*):

1. *People* – ensuring that no one is left behind, i.e. reaching out to socially excluded groups, creating conditions and opportunities for the exercise of universal human rights and access to economic achievement for all people.
2. *Planet* – building a development model which will foster economic growth, greater social inclusion and rational use of natural environmental resources, resulting in a better quality of life and solving the problem of poverty.
3. *Prosperity* – transforming economies in a manner conducive to creating jobs and guaranteeing inclusive growth by using new technologies and business potential, and providing access to good education, health care, and infrastructure.
4. *Peace* – fostering peaceful societies and effective, fair, open and responsible institutions that guarantee strengthening the role of law, social inclusion and co-decision, access to justice and non-discrimination.
5. *Partnership* – new global partnership building on solidarity, cooperation, responsibility and transparency of actions taken by all stakeholders at the global and local levels [Ministerstwo Rozwoju].

4. Main challenges of current food systems[7]

Food production has the highest environmental impact of any sector in terms of resources use at global level – however, in the European Union this is much lower. Food systems use many natural resources, including land, soil, water and phosphorus, as well as energy, for the production of nitrogen fertiliser, processing, packaging, transportation and refrigeration. Unsurprisingly, therefore, it also has an impact on the environment at the global level, including on biodiversity loss, deforestation, land degradation, water and air pollution, and greenhouse gas emissions. The continued loss of agricultural biodiversity at farm level remains a matter of serious concern [European Commission 2013]. Globally, a majority of fisheries are fully or over-exploited. Managing all of these resources efficiently and sustainably is, therefore, necessary to ensure a continued supply of healthy and affordable food.

Globally, a third of food produced for human consumption is lost or wasted[8], representing up to 1.6 billion tonnes of food and generating 8% of global greenhouse gas emissions [FAO 2011]. Producing food that will not be eaten con-tributes more than 20% of global pressure on biodiversity and consumes close to 30% of all of the world's agricultural land.

Only in the European Union are wasted about 88 million tons of food a year, and the associated costs are estimated at 143 billion EUR [European Commission 2014], which is expected to increase by 20% by 2020 if no preventive action is taken. Food waste in Europe is generated across the supply chain, with a concentration at household level estimated at 46% [FUSIONS 2016]. It should be noted that the retail and manufacturing sectors have made significant efforts to improve food waste prevention and reduction over recent years. Efforts to enhance production and supply chain sustainability make little sense without emphatic action to reduce waste.

Very little is currently known about food losses and food waste generation at farm level [FUSIONS 2016]. Food losses and waste, for example, can be generated due to lack of modernisation on some farms, order cancellations and commodity price volatility, resulting in the ploughing under of crops when it is not economically viable to harvest (but at least this has a positive impact on the environment as it contributes to improvement of soil organic matter content) or dumping and composting of food that cannot be resold.

[7] Developed based on [Opinia Europejskiego Komitetu Ekonomiczno-Społecznego w sprawie bardziej zrównoważonych systemów żywnościowych, Dz. Urz. UE z 19.08.2016, C 303/64].
[8] The UN definition of food loss and waste can be found at: [http://thinkeatsave.org/index.php/be-informed/definition-of-food-loss-and-waste].

Food systems are one of the causes of climate change; they are also set to be significantly affected by it [FUSIONS EU data set 2015; EC Preparatory Study on Food Waste 2011]. Climate change will have consequences for the availability of basic natural resources (water, soil) leading to significant changes in conditions for food production and industrial production in some areas [Komisja Europejska 2013]. Extreme climate conditions such as flooding, droughts, fires, and strong winds, as well as the further climate-related spread of plant and animal diseases, already affects food production and will do so even more in the future.

Undernourishment today coexists in the world with the effects of an over-abundance of food in certain parts of the world. Some 795 million people go hungry, while the number of overweight and obese people has reached more than 1.4 billion adults globally, representing about 30% of the total adult population; while obesity-related health conditions are rising rapidly in both developing and developed countries [WHO 2015]. These figures show profound imbalances in the way that food is produced, distributed and consumed. Population growth, and a forecast 82% increase in global meat consumption by 2050, will exacerbate both problems [WRR 2016]. During the past 20 years, as countries around the world have experienced urbanisation and economic growth, a nutrition transition has occurred, changing the face of food production and consumption. Worldwide, eating patterns are shifting to more composite products, more meat and dairy, more sugar and drinks containing sugar [Dutch Cabinet 2015]. At the same time, more people have a sedentary lifestyle contributing to a lack of physical activity.

Livestock plays an important and indispensable part in food systems, as a source of high quality protein and other nutrients such as vitamins and minerals. Livestock also plays a significant role in on-farm and regional nutrient cycles, and in protecting open and diversified countryside, permanent grassland and semi-natural habitats, as well as preserving biodiversity. It also provides people with income, assets and livelihoods. At the same time, the European Union also has a lot of agricultural land that in practice is suitable only for livestock grazing. However, over the last 50 years we have seen a more than fourfold increase in global meat and egg production, and milk production has more than doubled. During the same period, there was just a twofold growth in the global human population. It should be noted that the composition of the demand has also changed and that the increase in meat, milk and egg production is linked to income increase, whereas the prices have remained low.

Taking into account plant-based food grown for humans, plant-based feeds grown for livestock, and plant-based food crops used for seeds and industrial purposes such as biofuels, the world currently produces one and a half times the food needed to feed today's population, likely enough to feed the 2050 population. However, current levels of global food waste, and the production of animal feed to sustain increasing meat consumption, create a demand for a significant increase in food production. In order to feed the world sustainably in 2050 and beyond, a combination of productivity and optimisation gains on existing agricultural land and fisheries that is compatible with the stability and quality of the environment, with workplace health and safety and with social justice, as well as a shift towards sustainable diets, and a sustained reduction in food loss and waste is needed.

Increasing prices of agricultural products and agricultural inputs and price volatility over the past decade have been challenging food security and the robustness of the food system, while raising serious concerns for both consumers and producers. On the one hand, high end prices have not resulted in higher income for food producers, on the contrary, the reduction or stagnation of their income is exerting downward pressure on labour, threatening the income stability of all operators. On the other hand, the economic crisis has eroded the purchasing power of consumers. A stable and reasonable income for all operators along the food supply chain is necessary to ensure sustainable and steady further investments in agri-environmental technologies and climate-friendly techniques.

5. Key areas of intervention for a transition to more sustainable food systems[9]

A. Promoting more resource-efficient and climate-resilient food production

Reducing the environmental impact of agriculture, aquaculture and fisheries, including greenhouse gas emissions, requires changes in the way food is produced. The adoption of more sustainable practices is needed to halt the depletion of natural resources, as well as to adapt to and mitigate the effects of climate change. Several measures could benefit productivity while increasing environmental sustainability and resilience to climate change, such as increasing the diversity of plant and animal varieties, improving cattle through breeding, plant breeding, enhancing the functionality of agro-ecosystems and water management, promoting and applying research and innovation, optimizing soil function, facilitating knowledge transfer and training, and promoting technological changes through investment support. Further development of European Union satellite systems and big data centres should be promoted in order to facilitate early detection and prevention or preparedness for extreme weather conditions and different diseases. Precision farming should also be promoted.

[9] Developed based on [Opinia Europejskiego Komitetu…, op. cit.].

Maintaining the family farm model in Europe is also essential and would require the promotion of generation renewal on the farm, to face an ageing population. This would have a positive impact on job creation in rural areas. It is also important to be able to maintain diversified agricultural production across all regions of the European Union. Particular attention should be paid to disadvantaged farming regions. Different types of farms should be recognized and specific targeted tools should be put in place for this purpose.

In recent years, reorganizations of food supply chains have emerged with the aim of re-connecting producers and consumers and re-localizing agricultural and food production. These include community-supported agriculture, short supply chains, alternative food networks, local farming systems and direct sales. Even if the sector is relatively small, it should be promoted further, as it has very positive impact related to the sale of fresh, quality, healthy, heritage food with both social and economic positive impacts. SMEs are also important contributors in this field. The specific role of urban municipalities should be emphasized, as the required infrastructure and appropriate investments should be put in place in urban areas in order to facilitate producers' direct sales. Good private sector practices should also be encouraged, for example when such an infrastructure is created at the private initiative of local shopping centers.

To stimulate more resource-efficient food production, the reform of the common agricultural policy introduced a combination of measures, including mandatory greening, agri-environment schemes, and broad support from the Farm Advisory System and applied research, to address the challenges of food security, climate change, and sustainable management of natural resources, while looking after the countryside and keeping the rural economy alive.

As regards the fishery chain, it is important to ensure the right balance between healthy and sustainable, as the consumption of fish is healthy, but excessive pressure on fisheries is often diametrically opposed to ecological sustainability. The reform of the Common Fisheries Policy achieved in 2013 should contribute to a more efficient use of fishing resources, in particular through the mandatory objective of a maximum sustainable yield set for all European fish stocks. Sustainable development of offshore and inland aquaculture models is also important.

B. Fostering prevention and reduction of food waste along the food supply chain

In order to contribute to meeting United Nations sustainable development 12.3 goal target, halving food waste by 2030, the hierarchy of food use should be the guiding principle in managing food resources, and economic incentives should support this in all relevant European United policies. This would avoid the current situation where it is often cheaper to landfill edible food than to prepare and deliver it to food banks.

Sustainable management of resources also requires increased efforts to reuse residual flows at the highest possible value. New research comparing the cost of food preparation for redistribution, for animal feed, for anaerobic digestion and for landfill in the EU-28, would help to identify the role of economic incentives in the proper application of the European Union waste hierarchy. Food donation from the hospitality and food service sectors remains challenging and legislation around it, poorly understood. This is a key area where European guidance, widely circulated to hospitality businesses, would be particularly useful.

The 'Circular economy' package identifies the need to clarify the current guidance around the use of food, not fit for human consumption, as animal feed. Robust legislation regulating new food waste sterilisation technologies at a centralised industrial level, could ensure the microbiological safety of animal feed while creating new jobs and investment opportunities and reaping the environmental benefits of more effective application of the waste hierarchy. The European Union has been proactive in fostering activities to reduce food waste for a number of years.

C. Strengthening the link between food systems and climate change strategies

The impact of climate change is felt on all dimensions of food security – not only on yields and crops but also on farmers' health, the spread of pests and diseases, the loss of biodiversity, income instability, water quality, etc. Loss of arable land due to soil degradation and urbanisation of agricultural land is also a potential concern. Therefore, it is essential to maintain the priority of using land for food production. Institutions and the private sector play a crucial role in ensuring the resilience of food systems:

- by enhancing social protection schemes to reduce shocks for households and ensuring continuing investment in low carbon technologies in the agriculture and food sectors;
- improving crop diversification and the development of genetic resources;
- investing in resilient agricultural development, both on-farm and off-farm;
- and implementing systems to better manage risks related to climate change.

D. Promoting healthier and more sustainable diets

A healthy food choice is often a sustainable choice [Health Council of the Netherlands 2011], particularly within a balanced diet. For example, eating more seasonal, local and diverse plant-based foods is good both for health and the environment. A healthier eating pattern also reduces the risk of chronic diseases, the costs of healthcare and the loss of work productivity in the economy. Principles for developing healthy and sustainable dietary guidelines are needed, which can be considered by the Member States. Dietary and procurement guidelines have a direct impact on consumption where they are adopted by public institutions, such as schools and hospitals. It is also worth recognizing the nutrition transition under way globally, and the EU's role in providing a positive model on sustainable diets. A 'flexitarian' approach to reducing meat consumption, at least once a week, promoted for instance in the Netherlands, can be considered as a good example in this respect.

Initiatives such as the EU's school food scheme which includes nutrition counselling as well as the distribution of nutritious products contribute to more balanced diets. The Commission should invite Member States to stimulate healthy and sustainable consumption. The EU-wide healthy food visual advertising campaigns should be promoted; this could also be a good way of increasing local consumption during turbulence on the global markets.

As consumers have become more and more used to buying food products cheaply, the real value of food should be reemphasized. Low-cost products do not take into account externalities, such as the costs related to water treatment. As mentioned above, food education is needed in schools, along with an understanding of healthy dietary patterns and basic cooking skills that can support good health through home-prepared meals in line with nutrition recommendations as well as food waste reduction.

It is noted that the Dutch Ministry of Health, Welfare and Sport has initiated an Agreement for Improvement of Food Composition with producer, retail, catering and hospitality sector associations, making products healthier. This agreement includes ambitious targets on salt, saturated fat and calorie reductions in foodstuffs progressively to 2020, minimising noticeable changes in flavour profiles [Dutch Lower House 2014-2015, 32793, No. 162].

Product development, market development and key partnership building can help to make healthier and sustainable choices both easy and attractive. Industry and civil society should investigate and seize opportunities to increase the consumption of seasonal and local fruit and vegetables and other products naturally rich in fibres such as wholegrain food or pulses.

Implementing a clear labelling system on the origin, means of production and nutritional value of food would facilitate consumers' choices. Traceability is also very important both for food producers and for consumers, to ensure food safety. A single, easy to understand *sustainable food* label should be considered and its feasibility should be assessed by the Commission. More emphasis on technologies like mobile apps, and consumer displays in the retail sector, providing all the required information and full traceability should be further promoted.

E. Tackling animal and plant diseases to increase the robustness of the food system

The spread of animal and plant pests and diseases, exacerbated by globalised trade and climate change, has a detrimental impact on food systems. Recent outbreaks of African swine fever or of *Xylella fastidiosa* affecting olive trees in southern Italy are just some examples of how plant and animal diseases can disrupt the food system and generate food losses. While having nearly the best early detection and prevention system in the world, the EU's policy and legislative framework on animal and plant health could be further developed and reinforced with a stronger focus on crisis prevention, better surveillance and early detection, preparedness, and management, as well as on the identification and assessment of emerging or new risks both in and outside of the European Union. Early detection and prevention systems should also be reinforced, while ensuring that food producers and other operators (e.g. agricultural workers) are duly compensated for any losses, including for financial losses borne by farmers when trade restrictions are imposed in the public interest because of epidemic outbreaks. Furthermore, emphasis needs to be given to establishing more diverse farming systems which are more robust in terms of withstanding biotic stresses.

Research investment should concentrate on prevention and early detection, as treatment and eradication of an ongoing disease can be very costly and disruptive. Capacity-building and awareness-raising are essential, as is the transfer of knowledge from researchers to farmers and other operators. Knowledge transfer and cooperation with third countries are essential. The European Union should provide soft law, guidance, and tools for better surveillance, while stricter import controls are also crucial. Tackling resistance to antibiotics is also essential, and an integrated approach combining human and veterinary healthcare should be adopted – "One Health" approach.

***

1. Better coherence and integration of food-related policy objectives and instruments (e.g. on agriculture, environment, health, climate, employment, etc.) must be ensured taking into account the three pillars of sustainability.

2. A transition to more sustainable food systems encompassing all stages from production to consumption is greatly needed – producers need to grow more food while reducing the environmental impact, while consumers must be encouraged to shift to nutritious and healthy diets with a lower carbon footprint.

The European Union should step up efforts to implement the United Nations sustainable development goals (SDGs), as they provide a crucial framework for joint action to feed the world sustainably by 2030.

3. No food production system alone will safely feed the planet, but a combination of different conventional, innovative and agro-ecological practices could help to better address the environmental and climate implications of current food production systems. In particular, a mixture of precision agriculture, involving further development of ICT and satellite systems, and agro-ecology could complement conventional agriculture by providing a set of principles and practices intended to enhance the sustainability of farming systems, such as better use of biomass, improving storage and mobilisation of biomass, securing favourable soil conditions, fostering crop diversification and minimising the use of pesticides. Further promotion of closed agricultural models could lead to fossil-fuel-free agriculture. The reform of the CAP has introduced a combination of measures (greening, agri-environment-climate schemes, etc.), which can be considered as a step in the right direction.

4. A stable and reasonable income for all operators along the food supply chain is necessary to ensure sustainable and steady further investments in agri-environmental technologies and climate-friendly techniques.

5. Food waste prevention and reduction is a shared responsibility for all players in the food chain.

6. Sustainable food choices must be promoted by increasing their availability and accessibility to consumers. The consumption of sustainable food products should be encouraged by creating a stronger market demand, via green public procurement or other approaches. The European Economic and Social Committee calls on Member States to revise national dietary guidelines to reflect sustainability and to support food education in school curricula. The European Union should also promote origin labelling, the development of labels that clearly convey the sustainability aspect of food products as well as the EU-wide visual advertising campaigns for healthier food and diets.

7. The European Union policies, in conjunction with specific research and innovation programmes, combined with financial incentives to food producers, should:

- promote a gradual transition to fossil-fuel-free agriculture models;
- support a more efficient use of resources, including land, water and nutrients, across the whole production system.

8. A transition to sustainable food systems requires a comprehensive food policy, integrated with a broad-based bioeconomy strategy, not an agricultural policy alone [Opinia Europejskiego Komitetu…, op. cit.].

CHAPTER II

NON-INDUSTRIAL SUSTAINABLE INTENSIFICATION OF AGRICULTURE

The third green revolution in agriculture is today a necessity if this sector, being the basis of the functioning of societies, on a global, regional or local scale, is to meet the problems of the present and the challenges of the future. These problems arise from the contemporary dilemmas of providing food for a growing human population and the need for preservation of the natural environment and social justice. The growing population requires more food and more non-for-food products coming from agriculture, which are provided by growing and increasingly intensive production. What results in the growing negative pressure on the natural environment, which is the basic production resource in agriculture, and often also leads to adverse phenomena in the sphere of social relations. Thus, as noted by Nina Vsevolod Fedoroff et al. [2010], a major transformation of agriculture is needed – departure from the *status quo* to the benefit of forms of management which are different in qualitative and quantitative terms. In the wider context, the transformation of agriculture is a part of the transition from an industrial era to a new era of sustainability in all aspects of the civilisation development. Eric Holt-Giménez and Miguel Altieri [2013] stress, however, that such changes require, on the one hand, implementing a new rural development paradigm and, on the other far-reaching transformation of the current socio-economic system.

Walenty Poczta [2015] indicates that the first green revolution, which took place from the second half of the 19th century to the beginning of the 20th century, was linked to the development of natural science knowledge as a response to a sudden need for the increased agricultural production so as to feed the growing population of the world. The theory of humus plant nutrition by Albrecht von Thaer, the studies by Justus von Liebig explaining the basics of mineral plant nutrition or implementing on an industrial scale, by Fritz Haber and Carl Bosch, the catalytic process of generating ammonia from atmospheric nitrogen underpinned the dynamic development of agricultural production induced by technological innovations related mainly to nutrition and fertilisation of plants [Antonkiewicz and Łabędowicz 2017]. Thanks to the effective chemisation of agricultural production and the use of the achievements of the second green revolution in the 1980s, being a result of implementing biological progress, the technological ability to feed people on a global scale has been obtained. The founder of the new green revolution was Norman Ernst Borlaug, who won the Nobel Peace Prize for his activity in 1970. Cultivation of very fertile wheat and maize varieties with the high protein content and their implementation into the large scale agricultural production contributed to increased food production, to cover the needs of the world, but did not solve the problem of feeding the population [Rutkowski 1989]. Harold Brookfield [2001] stresses, however, that the transformations were determined not only by technological innovations but also by capital investments and growing skills of farmers as regards the use of knowledge on organisation and management. Through implementing various forms of progress into the agricultural production under the first and second green revolution, it was possible to increase the agricultural production from one unit of managed land or from one animal, and thus to increase the productivity of agriculture [Pretty and Bharucha 2014]. The intensification of the agricultural production allowed to increase the production even in the case of the decreased area of farmland or number of animals. This was done in line with the assumptions of the Neo-Classical growth theory, which, through the reductionist approach, put an emphasis on achieving the high productivity with the greatest possible exploitation of natural resources in the short term, treating agriculture as a closed mechanistic system. However, intensive industrial agriculture led to the accumulation of critical mass of negative effects, in particular externalities, which resulted in an extreme, in some cases, inefficiency and which occurred in four major civilisation development perspectives (economic, social, environmental and institutional).

From the economic perspective, on the supply side, there was the escalation of the agricultural production towards the intensive industrial production in specialised companies seeking to obtain the market domination advantages and also the marginalisation of small farms, which, unable to achieve the required economies of scale, became uncompetitive on the market. As a result, on the micro-scale, the technological treadmill gathered speed [Valenzuela 2016, Czyżewski and Henisz-Matuszczak 2005, Thirtle et al. 2004], while on the macro-scale, the domination of international and global corporations was growing. They distorted the institutional order by imposing on the market not only business price dictate [Clapp 2009], but also the institutional dictate, whose implications have a much more serious aspect affecting structural changes in agri-food systems in the long term [Lang and Heasman 2015, Maciejczak 2002]. On the demand side, the effect of the existing agricultural development path have become not only the growing problems of hunger and malnutrition in the growing population of the world or economic inequalities, including income inequalities, but the general deterioration of social well-being [Rosin et al., 2012].

Thus, from the social perspective, as indicated by Józef Stanisław Zegar [2017], social well-being, which includes the material and immaterial conditions of life and social order (disproportions and inequalities in society, food and social security, inclusion of social groups in shaping forms of collective life, eliminating unemployment and social exclusion, preserving the values of the natural environment for future generations, preserving social and ethical norms) has not only been distorted but also significantly undermined, thus spontaneous, internal corrective actions became simply impossible. The global corporate system, based on industrial agriculture, does not foster social cohesion leading to the occurrence of, *inter alia*, social negative externalities, such as the depopulation of rural areas, the rise in unemployment, elimination of smaller producers and processors, reduction in the food quality [Zegar 2017]. At the same time, studies by Linda Lobao [1990] confirmed that social ties, trust and participation in local life, as well as care for the environment on a local scale are greater when the size of the farm is smaller. Additionally, Gabrielle O'Kane [2012] and Barry Popkin [1993] pointed to changes in consumption patterns – particularly in the developed countries. Along with a significant increase in the consumption of sugar and saturated fats, the food-based health problems of societies are growing, resulting from, *inter alia*, obesity and related lifestyle diseases, while with the increased consumption of meat, the problems, *inter alia*, with antimicrobial resistance are growing.

From the environmental perspective, the domination of the Cartesian view on "nature as a machine" whose worthiness is determined by its usefulness for humans, was based on the long-term separation of socio-economic objectives from environmental needs. This led to a gradual erosion of immanent connections of humans and their activity with nature. As a result, two, increasingly isolated entities were created – humans with their artificial agricultural production systems and natural ecosystems exploited for their needs. Many authors, including, *inter alia*, Lummina Horlings and Terry Marsden [2011], Stanisław Krasowicz [2009], Bogusław Fiedor [2006] or Stephen Gliessman [1990] stress that such actions led to a significant deterioration of the environment, in particular the land quality, which is actually the primary production resource of agriculture and a key factor determining the biological and social quality of food produced. At the same time, when the intensive agricultural production was conducted industrially, no internalisation of negative, mainly environmental, externalities of such activities has been done. Józef St. Zegar [2017] indicates that the pressure exerted by industrial agriculture on the natural environment cannot be maintained in the long run. The global ecosystem (biosphere) is finite and contains limited resources both in terms of raw materials that can be used for the needs of the economic development (soil, water), as well as the possibility of accepting and eliminating emissions resulting from the economic development and the anthropocentric pressure in general (soil erosion, water pollution, loss of biodiversity, greenhouse gas emissions).

The need to offset the economic, social and environmental objectives in the new model of agricultural development is today a necessity, and also the starting point for the search for directions and paths of transformation in the 21st century. Nikos Alexandratos and Jelle Bruinsma [2012] and also Jeremy Allouche [2011] showed that Neo-Malthusian narratives proving that the world urgently needs to produce more food for the growing global population, and that food security can be ensured only by maintaining the current model of high-volume industrial agriculture are utopian. At the same time, there is broad consensus as to the direction of necessary changes. In the last decade, numerous authors, representing various fields of knowledge, agreed that agriculture should be developed comprehensively, by balancing the demands of ensuring food security, economic development, social prosperity with a need to build an ecological balance through reducing the negative environmental impact, increasing natural capital and expanding streams of environmental services. Thus, the marginalised environmental factor starts to lead in a new model of agricultural development and influence the anthropogenic factors. As Józef Stanisław Zegar [2012] explains, this is related to the determination of the growth limits of a given ecosystem and the indication of whether the marginal usability of the growth is lower or higher than the scale of lost profits, thus, whether the system is able to renew itself. Such a reversal of the roles set for manufacturing agents fully matches the grounds of the third revolution in agriculture.

At the same time, such actions, in particular from the economic perspective, require a comprehensive and holistic recognition of agriculture and its environment through the prism of interdependent and complex adaptation systems. The new model of sustainable agriculture must, therefore, not only be efficient in economic, social and environmental terms, but also must be characterised by high adaptation efficiency [cf. North, 1992]. As demonstrated by Jacek Unold [2003], individual, unpredictable and often irrational activities of individuals constitute the adaptation process of behaviour of communities. It can, therefore, be concluded that, in this situation, the systemic rationality means that the irrationality of individuals making up the given system does not necessarily result in irrationality of the whole system. Hence, if in the real economic reality there are difficulties in applying the rules of classic optimisation principles, we must understand adaptation actions as rational behaviour. In this way, the reasonable choice of objective is not dependent solely on the subjective preferences of the individual, but mainly on the external conditions and internal functioning of the system that adapts to these conditions. The adaptation effectiveness is determined primarily by institutional solutions that dynamically and flexibly allow to separate private rationality from social rationality and to create conditions not only for competition or cooperation but also for coexistence [Maciejczak 2016a].

As part of the third green revolution, it is necessary to increase the production efficiency while ensuring that such actions do not cause irreversible damage to the environment. Such expectations are exemplified by the concept of sustainable intensification of agriculture. But there is still a question of the way, leading to the development of a model of agriculture which is both intensive and sustainable. As demonstrated by, *inter alia*, Mariusz Maciejczak, Tadeusz Filipiak and Henryk Runowski [2017] there are two main and most probable ways thereto – industrial and alternative. These authors stated that industrial intensification is a natural consequence of the currently applied solutions aimed at increasing the productivity and efficiency of major means of production, whereby what is mostly used are technologies putting an emphasis on quantitative rather than qualitative changes, most often within a single mean of production.

There are, therefore, questions on what is an alternative, namely non-industrial sustainable intensification of agriculture and how and to what extent this way allows to meet the challenges faced by agriculture of the future. The objective of this paper is to present and evaluate the concept of non-industrial sustainable intensification of agriculture. The paper is based on a critical review of the opinions presented in the literature of the subject. It is complemented by own studies using the foresight method. The real-time Delphi method was used [cf. Maciejczak 2016b]. The study conducted in 3 cycles between June and August 2018 was attended by seventeen researchers from nine countries (Poland, Hungary, Czechia, France, Cyprus, the United Kingdom, Germany, Israel, the United States).

1. Genesis of the occurrence of the non-industrial way for intensification of agriculture

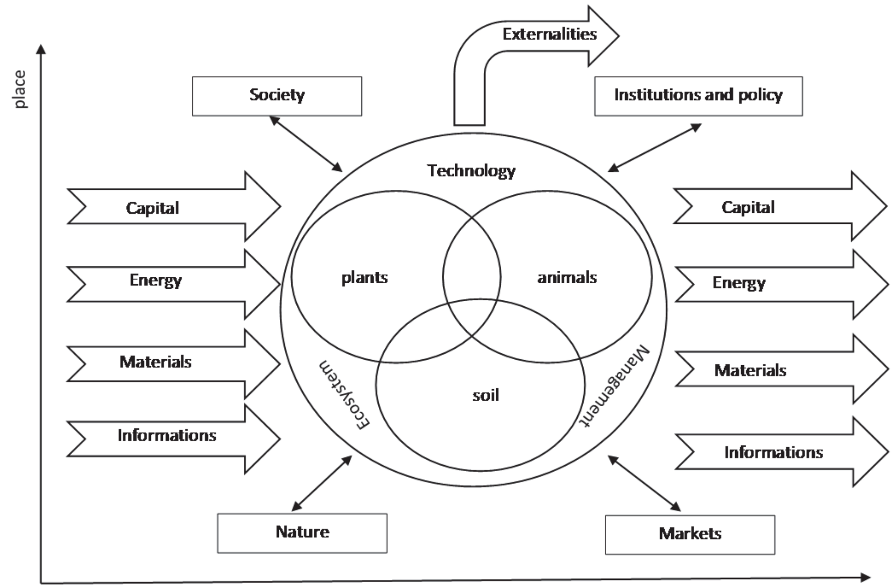
Given the ontological primacy of nature in the revolutionary changes in agriculture paradigms as part of the third green revolution, the starting point for an epistemological analysis of non-industrial sustainable intensification of agriculture is the systemic nature of the environment. As Larry Phelan stresses [2009], it is the systemic nature of the environment which determined the conduction of the agricultural production and its functional unit is an ecosystem. With regard to agriculture creating a hierarchically structured system based on the functioning of ecosystems transformed according to human needs, the model of agroecosystem is created [Ikerd 2009]. The agroecosystem is a general model representing the structure and functioning of I/O-based agriculture, where socio--economic and biophysical elements are fully integrated into the continuous production and consumption process on any spatio-temporal scale [O'Leary and Chia 2007].

John Ikerd [2009] stressed that the integration of the ecological approach with the perception of agriculture through the systemic prism aims primarily at improving the sustainability of agriculture. At the same time, Roy Lowrance et al. [1984] note a need for a hierarchical perspective, so that the concept of agroecosystem is like a lens focusing on the agricultural reality at different levels of resolution, assuming the local, regional and global perspectives different as to the assumed and achieved goals, but harmonised using a single paradigm of sustainability. According to Mirjam Westra and George Boody [2009], the ultimate objective of integrating ecosystems and agriculture is the functioning of the whole agroecosystem. This is due to the fact that ecosystems are self-organising and sustainable parts of the biosphere, and the biosphere is the entire self--organising and sustainable planetary ecosystem. Thus, the ecosystem representation of reality reveals an ontological relationship between ecology and sustainable development of agriculture. The sustainability is the highest property of agroecological systems, resulting from their intrinsic ability to self-organise, be resilient and adaptable. A holistic aspect of agroecosystem is shown in Figure II.1.

As justified by Vittorio Tellarini and Fabio Caporali [2000], agroecology recognises the value of tradition in agriculture, determines a scientific justification for good practices of traditional agriculture and recognises their importance as a basis for sustainable agriculture intensified using the developed and still developing knowledge based on the scientific discoveries considered to be a production factor and one of the key components of the system. It can, therefore, be concluded that, in a sense, the concept of agroecosystem is a return to the roots of agricultural production and adaptation of its foundations to new challenges.

However, Norman Uphoff [2014] points out a need to set specific boundaries for individual elements and the whole agroecological system, so that it was possible to analyse the causality of specific phenomena, not in mechanistic but in holistic terms – as an interaction of individual elements of the system within its framework and between the system and its surroundings.

Figure II.1. Holistic aspect of agroecosystem



Source: own study based on [Caporali 2010].

An example of such approach is a concept of developing holobionts in agricultural production described in Box 1. From the perspective of such strategy it is needed to be noticed that the current conventional agriculture relies heavily on high nutrient inputs that will be taken up directly by the plants. In these systems, plants are considered as sole players, disregarding plant traits that can improve the recruitment of beneficial soil microbes for nutrient mobilization and plant protection. As a consequence, conventional practices have resulted in low nutrient use efficiencies, groundwater pollution and increased soil erosion to non-sustainable levels. High loads of synthetic and organic fertilizers as well as synthetic pesticides have made many beneficial soil biota, especially microbes, redundant. Their multifunctional ecosystem services have been replaced with single-purpose synthetic additives designed to support and protect plants directly, and their interactions with the plant have been neglected in breeding strategies. However, the greater the belowground diversity in the soil, the better the prospects of plant roots to recruit beneficial microbes to mobilize nutrients, reduce stresses and suppress pathogens. Nutrient use efficiencies increase with improved microbial nutrient recruitment alongside a reduced fertilizer dependency and lowered groundwater pollution.

One could doubt if such holistic agrobiological approach to plant production will eliminate other human genius achievements resulting in technical or biological progress, which were successfully implemented so far and ensured successes, such as synthetic fertilisers or pesticides, new varieties. The answer is simple and unequivocal – no! Simply, the agroecological approach is changing the gravity point. While the industrial agriculture became increasingly dependent on the reduced and simplified factors very often of the artificial origin, the agroecological strategy is focusing on the holistic natural processes as a primary productivity factor. However, it does not mean the elimination of the so far used technical, technological or biological progress' elements from the system, it means the change of their role and the scale of use. The *sine qua non* condition for such change is the understanding of systemic nature of agricultural production and implementation of the progress (or more precisely innovations) from such perspective. People achieved already the critical mass of knowledge on natural processes, but use it in a limited and very selective way.

BOX 1. THE CONCEPT OF THE PLANT HOLOBIONT

The dynamic interactions between soil microbiome, plant microbiome and plant fitness are tightly linked to agricultural practices and as such need to be jointly tested to promote sustainable agriculture. Thus, by taking the concept of the plant holobiont and explicitly aim in plant breeding and agricultural practices to selectively enrich with beneficial indigenous microbes, one can enhance the ability to manipulate or direct plant-microbiome interactions, thus using positive plant soil-feedbacks to reach crucial benefits.

From the socio-economic point of view: Harnessing plant microbiota can assist in sustainable development and provide effective solutions for growing global challenges. These challenges arise primarily from increasing human population requiring more safe food, global climate change resulting in temperature growth, extreme weather events including reduced water availability and water sanity or emerging pests or pathogens [EPSO 2017]. At the same time, high quality land areas allowing for crop production decreased worldwide, creating a challenge for sustainable land strategies that ensure productivity through resilience and biodiversity [Zarraonaindia et al. 2015]. Sufficient food quantities are required, but also the production of food of high nutritional quality with minimal or no chemical, allergen or toxin concentrations has to be feasible. All these aspects create a growing tension for sustainable agricultural production. Importantly, the substantial increase in food production observed in the last century – achieved through breeding of plant lines with desirable traits such as high yields, nutritional quality, pest or pathogen resistance and improved tolerance to abiotic stress – led to an intensified agriculture production and a global crop production that relies heavily on external inputs such as pesticides or inorganic fertilizers [Hamonts et al. 2018]. Harnessing plant microbiota in agriculture creates arising opportunities for development of sustainable agricultural sector following the path of biological intensification as a realistic and rational alternative to the today dominant industrial intensification. In this context, the impact of plant microbiome interactions goes beyond the direct impact on plant health and nutrition by influencing the economic, social and environmental aspects of agro-ecological and socio-economic systems.

continued BOX 1.

From the economic point of view already a few examples of beneficial plant-microbiome interactions are well investigated and explored with regard to their importance in agricultural systems. These include biological nitrogen fixation by rhizobia, which establish a symbiosis with legumes and represent the basis of crop rotations including legumes contributing to the maintenance of soil fertility [EPSO 2017]. The US-based start-up company Indigo believes it can obtain 30% to 50% yield improvements over the next 10 years for cotton, rice, wheat through intensification of plant interactions with the microbiome. The improvements also promise to save water and reduce the need per unit of production for fertilizers, fungicides and pesticides. Indigo reported a 6% to 8% improvement in yield increases in water-stressed environments in wheat, cotton, soy and rice [Schenker 2017].

From the environmental point of view, considering the importance of plant-associated microbiota for host and ecosystem functioning, the exploitation of microbial activity could provide means to achieve several goals on different levels. The application of microbial products with plant growth-promoting or biocontrol activity could, at least partly, substitute agrochemicals, thereby reducing their release into soil and water and consequently the negative effects on the environment [Sessitsch et al. 2018]. The activity of plant microbiota can further enhance the efficiency of phytoextraction, as many bacteria mobilize metals in soil and so facilitate the uptake by plants [Thijs et al. 2016]. Others promote leaf growth, which in turn allows incorporation of higher amounts of metals per plant. These microbe-assisted processes could also be employed as gentle and less-invasive alternative to conventional mining, by extraction of valuable metals accumulated in plant tissue [Berg et al. 2014]. Furthermore, plant microbiota partnerships enable clean-up of soils and groundwater from different organic pollutants [Sessitsch et al. 2018].

From the social point of view the activities of plant-associated microbiome can also affect human health and well-being. The microbial-based management strategies for reduced use of agrochemicals or soil and water sanitation mentioned above will, certainly, have positive effects on human health by reducing the exposure to potentially harmful chemicals and metals. However, the plant microbiome can also directly affect humans, as it consists not only of plant beneficial, neutral and plant pathogenic bacteria but comprises also potential human pathogens, which are taken up by the human body through consumption of raw plants such as vegetables and fruits. Furthermore, it was assumed that plant microbiota is interconnected with those of humans also via air, soil, animals and indoor environments. Consequently, strategies to ensure healthy and balanced plant microbiota, such as prebiotics for plants, could play an important role in preventing disease outbreaks in humans [Berg et al. 2014].

All these factors have led to an increasing awareness of the functions that plant microbiome could play for agricultural sector and beyond in the agro-ecological and socio-economic systems [Sessitsch et al. 2018].

Nevertheless, there are still a number of solutions to investigate in the application of plant microbiota, and we are just at the beginning to realize their full potential contributing to economic growth and sustainable development.

Alexander Wezel et al. [2009] indicate that agroecology can be recognised as a social movement, a science or a set of agricultural practices. The use of the term "agroecology" dates back to the 1930s [Hecht 1995]. The creator of the term and concept of agroecology is Basil Bensin [1930], who pointed to the importance of using organic methods in the cultivation of agricultural plants. Until the 1960s, agroecology referred exclusively to a purely scientific discipline. Its other branches were then developed. Following the opposition of the scientific and consumer communities, which was addressed against industrial agriculture, agroecology evolved and supported social agroecological movements in the 1990s. Agroecology as an agricultural practice appeared in the 80s and was linked to the implementation of organisational innovations into agricultural production by developing the concept of organic or bio-dynamic farming on a broader scale [Werner 2007]. The directions, scales and aspects of agroecological studies have changed over the past decades, from the scale of the parcel and field, through the scale of the farm and local agroecosystem, to the scale of the food system.

According to Miguel Altieri [1989], three approaches to analysing agroecology can be indicated: (1) field studies, (2) farm-scale studies and (3) studies covering the whole food system. These approaches are manifested in different definitions of agroecology. Stephen Gliessman [2007] defines agroecology as the science of applying ecological concepts and principles in the design and management of sustainable food systems. For Charles Francis et al. [2003], agroecology is an integrated approach to whole food systems, covering ecological, economic and social aspects. However, David Clements and Anil Shrestha [2004] concluded that agroecology is a new philosophy of agriculture involving systemic thinking and local adaptation, using autonomous mechanisms of plant and animal resilience, covering the agricultural landscape, material cycle closure, production technologies, human ecology and natural aspect. In examining the above, selected definitions it can be considered that crucial for the development of agriculture based on the intensification in an alternative way are holistic concepts stressing the systemic nature of agroecology by referring it to the concept of agroecosystem.

2. Types of non-industrial intensification of agriculture

As Niamh Mahon [2017], points out the term of sustainable intensification was developed to capture the concept that some consider to be a new paradigm for the global development of agriculture. However, the term has been the subject of intense debates, as well as of scepticism and ambiguity as to its importance. At the same time, Paul Struik et al. [2014] stress that, given that the definitions of both intensification and sustainable development differ considerably, the way in which these concepts are used in different disciplines causes tension and numerous interpretation misunderstandings of multidimensional aspects of sustainable intensification, which significantly impedes scientific discourse and application activities. Nic Lampkin et al. [2015] note that the concept of sustainable intensification is more complex than just the concentration on inputs or outputs and that the simple definition of "produce more for less" is very insufficient. It should be emphasised, at the same time, that, while there are differences between the definitions proposed by different authors that go far beyond semantic boundaries, these authors often use specific terms in a free, often opposing, manner [cf. Himmelstein et al. 2016; Tittonell 2014 or Bommarco et al. 2013].

In the context of the resulting terminological confusion, first of all, three levels of analysis of the issue in question should be distinguished. Firstly, as a point of reference we should adopt a paradigm of agricultural sustainability which imposes a need for intensification. It is, to some extent, a meta-level of scientific discourse as to which there is consensus in the literature of the subject [cf. Foley et al. 2011]. A thorough review of the definition at this level of analysis has been done by Jakub Staniszewski [2018] in his doctoral thesis noting that, on the one hand, a need to improve production efficiency is emphasised while, on the other, it is required that this improvement should not result in environmental damage. Secondly, it is necessary to distinguish between the two ways of implementing this paradigm, adopting the degree of industrialisation as a criterion. Thus, industrial sustainable intensification and alternative non-industrial intensification appear. The third level, however, is the detailed consideration of each way individually, with various proposals of both conceptualisation and operationalisation. For the purpose of this paper, a third-level analysis has been adopted with respect to conceptualisation of the types of non-industrial sustainable intensification.

The literature review made it possible to distinguish four main types of non-industrial sustainable intensification of agriculture. These are:

1. Agrobiologic intensification.
2. Ecologic intensification.
3. Sustainable intensification.
4. Agroecological intensification.

Table II.1 lists the selected definitions of alternative ways of agricultural development through non-industrial intensification.

Table II.1. Selected definitions of alternative ways of agricultural development through non-industrial intensification

Type of intensification	Authors
AGROBIOLOGIC intensification	
Intensification of agricultural production with the use of available genetic resources and their specific characteristics based on synergy strategies.	Abberton et al. 2015
Use of agrobiologic processes in increasing the productivity of basic production factors. An important role is played by extensive knowledge of farmers which translates into the quality of agri-environmental practices and the use of traditional and modern production technologies.	Wrzaszcz 2017
ECOLOGIC intensification	
Maximisation of the primary production per production unit without prejudice to the system's ability to maintain the production capacity.	FAO 2014
Intensification of the use of natural functions offered by ecosystems.	Chevassus and Griffon 2008
Its task is to preserve and promote biodiversity and sustainable use of related ecosystem services to support the resource-efficient production; it requires fundamental changes in the agricultural and landscape economy as well as organisations and institutions supporting agriculture.	Geertsema et al. 2016
Its based on management of services provided by living organisms which create a measurable, direct or indirect contribution to the agricultural production; supporting and regulating ecosystem services provided by these organisms can be included in farming systems so as to maximise the production and the environmental impact is minimised by a reduction, but not necessarily exclusion, of anthropogenic factors such as non-organic fertilisers, pesticides, energy or irrigation.	Bommarco et al. 2013
Agricultural systems using ecologic processes and services.	Tittonell and Giller 2013
SUSTAINABLE intensification	
The process of research and analysis to navigate and organise problems in agronomy; the point is social negotiations, institutional innovations, justice and adaptive management.	Struik and Kuyper 2017
Increase in the production from the same area, while decreasing the negative environmental impact and increasing a contribution to natural capital and flow of environmental services.	Pretty et al. 2011
Inclusion of adequate practices in the whole value chain of the global food system, which will meet the growing demand for nutritive and healthy food thanks to actions building socio-ecological resilience and increasing natural capital in the safe operational space of the Earth system.	Rockström et al. 2017
Synergic capacity of the production of agricultural and natural capital.	Pretty et al. 2018
Agricultural process or system in which expected (production) results are maintained or increased or at least are maintained and aim at significant increasing of environmental effects; this covers the rule of acting without farming larger amount of land (and thus the loss of naturally valuable habitats) where the increase in the overall capacity of the system does not result in net environmental costs.	Pretty et al. 2018

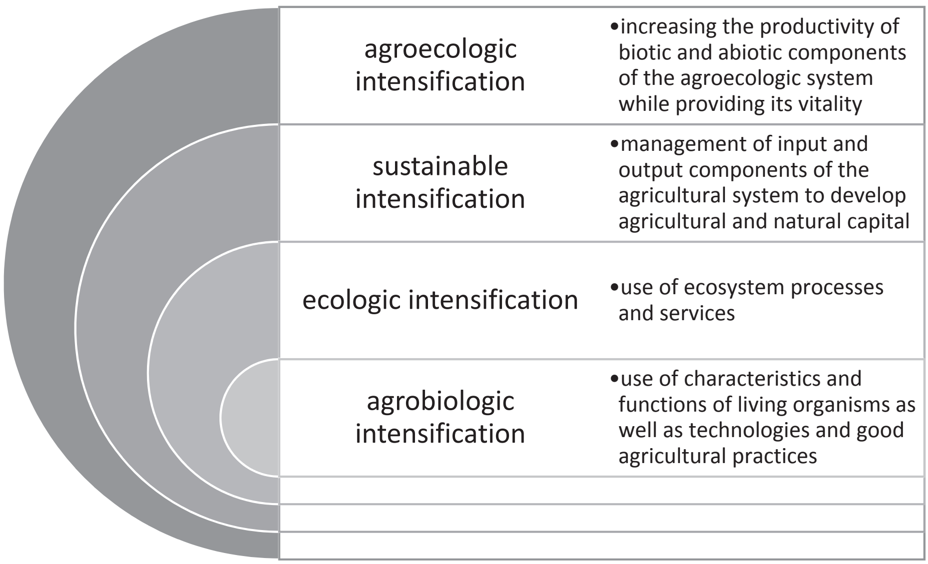
continued Table II.1

Handling input and output factors (of the agricultural system) to increase the productivity and/or production while maintaining the integrality of both the system and environment.	Gibon et al. 1999
Intensification of the agricultural production with the use of natural, social and human capital resources in combination with the use of the best available technologies and means which minimise environmental damage.	Pretty 2008
AGROECOLOGIC intensification	
Includes ecological rules in agriculture management, to reduce the dependence on external factors and increase the productivity of biotic and abiotic components of the system.	Milder et al. 2012
Maintains ecosystem services while minimising environmental costs and preserving functional biodiversity thanks to wildlife-friendly agricultural systems.	Tscharntke et al. 2012
Improved agricultural productivity by integrating ecological rules with farm management.	CCRP 2013
Set of improved input factors, tools and practices which provide better productivity per unit of inputs when compared to traditional practices, whereby the efficiency of using these factors is maximised.	Vanlauwe et al. 2013
Approach towards management which integrates ecological rules and biodiversity management into agricultural systems so as to increase the productivity of farms, decrease the dependence on external inputs and maintain or strengthen ecosystem services.	Garbach et al. 2016

Source: own study based on the above-quoted authors.

The analysis of the above definitions confirms the argument that, so far, there has not been one coherent way of agricultural development through non--industrial sustainable intensification. The definitions quoted relate to objectives, principles and means. The lack of conceptual coherence, however, is not an obstacle to determining, based on the above-mentioned definitions, the typology of ways on non-industrial sustainable intensification of agriculture, depending on the scale of impact. The narrowest aspect is agrobiologic intensification which accentuates the use of biological characteristics and functions of living organisms (environmental component) as well as technologies and good agricultural practices (agricultural component), which together allow for achieving the sustainable development goals. A slightly broader perspective is outlined by ecological intensification, which focuses on management of ecosystem processes and services. The systemic perspective is also assumed by sustainable intensification, however, putting an emphasis on the agroecosystem management that should result in development of natural productivity. The broadest perspective is agroecologic intensification, which generally captures the overall animate (plants, animals and biodiversity) and inanimate factors, including capital, functioning within the framework of a system, with the aim to its development by providing resilience and vitality. The relationships between the various types of alternative agricultural development ways through non-industrial intensification are shown in Figure II.2.

Figure II.2. Relationships between the types of alternative agricultural development ways through non-industrial intensification



Source: own study.

The scientific literature also provides critical views relating to alternative ways of sustainable intensification. In view of the fact that organic farming is the largest as to the production scale and speed of development, this criticism applies most frequently to this production system. González de Molina [2015] notes that the greater profitability of organic farms encouraged producers who are more interested in subsidies and higher prices than the organic way of producing food to enter the sector. In view of the fact that the organic production system is an artificial system based on man-made principles, it is often distorted towards anti-environmental actions [Fuglie and Kascak 2001]. This is due to the fact that regulations, irrespective of the legal system, allow to use selected pesticides and fertilisers and practices which, under certain conditions and for certain crops, enable more intensive work of soil, shorter crop rotations, etc. For example, in organic orchards soil may be over-cultivated, causing wind erosion, which can be as serious as that caused by traditional cultivation. Juan Infante-Amate and Manuel Gonzalez de Molina [2013], and Pablo Tittonell and Ken Giller [2013] argue that the result of such actions is usually an increase of "conventionalisation". By this they mean that organic farming is becoming a version that reflects conventional farming, reproducing the same way of development. The conventional logic of the food market is putting pressure on organic producers towards intensification, if this pressure is not prevented by institutional mechanisms, however, they involve specific transaction costs.

Manuel González de Molina and Gloria Guzmán Casado [2017] argue that both sustainable and ecologic intensification do not meet the permanence criterion, as they do not have thermodynamic foundations. Intensification cannot be kept endlessly in a finite, closed world and is, therefore, not permanent. They state, however, that, at a specific point and for a limited period, the non-industrial development of agriculture can be permanent, if intensification occurs in accordance with the agroecological criteria. They consider that the only sustainable way to further intensify the agricultural production without destroying natural resources is the use of agroecological methods – for example, through crop rotation, enhancing biodiversity, including legumes in fields, use of agroforestry techniques, etc. This could be the best way to reduce the productivity gap, which is present today between conventional farming and organic farming.

Also Alexander Wezel et al. [2015] point to the issue of the period of analysis and the importance of knowledge. They state that the sustainability and intensification are right directions but effective in the short term only. In addition, the agroecologic intensification puts a strong emphasis on the intensification of knowledge, in order to better understand many components of agroecosystems, and in particular to strengthen the cycles between various biological, chemical and mineral components to achieve the higher productivity. Achieving the sustainable development thus requires a lot of effort to better understand agroecosystems and the role of researchers working with farmers is of paramount importance. Additionally, Jonathan Mockshell and Josey Kamanda [2018] think that non-industrial intensification of agriculture requires a much broader approach to the system analysis and a need to recognise not only synergies but also compromises between socio-economic, ecological and institutional aspects.

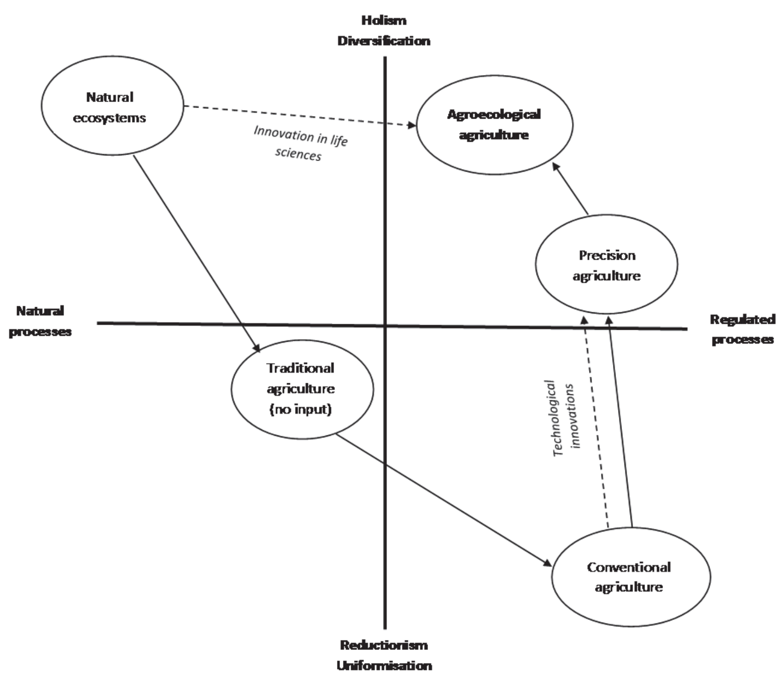
3. Differences between the non-industrial sustainable intensification of agriculture and alternative intensifications

In a holistic manner, one should refer critically to the definitions laid down in the previous chapter, showing that they significantly restrict or excessively simplify the systemic nature of agriculture intensified non-industrially. This nature largely determines the specific grounds of the chosen way of development, making it not only alternative, but also revolutionary, and it is, in fact, at stake [cf. Bonny 2011]. The objectives, ways and means of non-industrial sustainable agricultural development, as described in these definitions, do not highlight the need to develop a sustainable system based on broadly understood agroecosystems, immanent elements of which are economic, socio-economic, ecological and political-institutional aspects. These needs were described by, *inter alia*, Curtis Beus and Riley Dunlap [1990], and Gaël Plumecocq et al. [2018]. As regards the socio-economic and institutional efficiency, the definitions in question do not indicate a need to decentralise and move from the scale of global food systems to local supply chains or distributed control over production factors. Thus, they do not highlight another aspect, namely, independence, understood not only by the prism of the decisions made, but also in the context of self-sufficiency (e.g. energy or capital). Factors of decentralisation and independence are the foundations of the local community, which to a larger extent, accentuates local rural communities, cooperation of various stakeholders within these communities, preservation and development of tradition and culture.

In contrast to the industrial way, the model of agriculture intensified non-industrially should include systems based on widely understood diversity, also biological, social and economic [Borrás and Edler, 2014]. The decisive diversification as to the scale and time of such a system of agriculture is based not only on management but also on the development of ecosystem services and the holistic increase of economic, social, agricultural and natural capital. The key to development is the localness and adaptability in the short and long term. This requires the integration of key diversification factors, in particular, collective, multiservice agricultural landscape management, development of alternative food systems, circular economy and application of local knowledge. Thus, the adoption of a local systemic perspective justifies not only the choice of production methods based on the action of nature (e.g. organic farming) but also the development of short supply chains. In addition, as stressed by Michel Duru et al. [2015], nature in this model is understood as an organised set of elements, which has its production value due to which its use requires testing and adaptation.

At the same time, the model of industrial sustainable intensification of agriculture is based on intensive inputs in production factors and is implemented on specialised farms. As Terry Marsden [2012] points out, it operates within the framework and according to the rules of the globalised food system. In order to achieve the basic objectives of the sustainable development, in particular the reduction of environmental damage, an emphasis is put on the development of smart agricultural technologies (i.e. genetic engineering or precision farming) or on knowledge of landscape features that minimise the diffusion of ecosystem pollution (e.g. buffer zones). In this technically intensive model, changes are made in the belief that mastering technologies can meet environmental requirements and reduce production costs, and thus improve farmers' income and provide food security. By integrating the latest scientific knowledge with decision-support systems, this system can improve the environmental efficiency, *inter alia*, by reducing soil, water and atmosphere pollution. At the same time, the system is still vulnerable to market and production shocks. The economic resilience of such a system of agriculture to the price volatility and biophysical risk can be supported by contracts and insurance schemes or globalised food supply chain organisations. These safeguards can lead farmers to increasing the share of more risky crops, which results in the increased share of monocultures. In addition, when farmers adapt expensive new technologies, they often increase the cultivation area to provide economies of scale. Thus, as noted by Frank Geels and Johan Schot [2007] this system is often poorly related to local social problems and management strategies for local natural resources. The search for efficiency and profitability justifies the use of technology, making it a part of the com-promise between the economic and social optimum. Therefore, this system can be seen as an update of the conventional model.

Figure II.3. Evolution of agricultural systems from a sustainable development perspective



Source: own study based on [Griffon 2013].

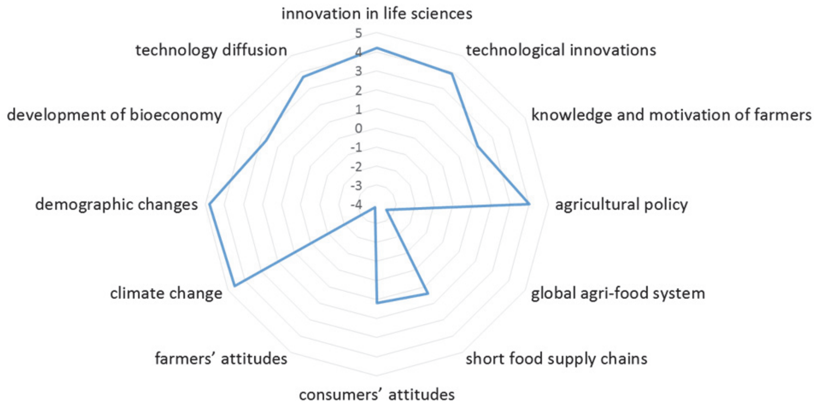
In view of the above, we can support the opinion by Jacqueline Loos et al. [2014] who claim that the current use of the term "sustainable intensification" can be potentially misleading as it inadequately refers to the main principles of the sustainable development. They highlight the critical shortcomings in the definitions of sustainable intensification and call for more holistic assessments, including a clear consideration of distribution and social justice as well as institutional governance. This requires departing from global analyses and adopting a local or regional perspective. Figure II.3 illustrates the evolution of agricultural systems from a sustainable development perspective.

4. Factors determining non-industrial sustainable development of agriculture and its potential impact on achieving the goals of the Agenda for Sustainable Development 2030

The vision of the agricultural production intensified non-industrially and implementing the objectives of the sustainable development paradigm still constitutes an *ex-ante* assumption. A broad, interdisciplinary scientific discourse on this way of agricultural development is, to a smaller extent, carried out in decision-making groups, while it is negligible among the farmers concerned [Hazel and Wood 2008]. It is also worth adding that as far as broad consultations are carried out on a global scale, on a local scale we can observe the lack of interest in this issue. Despite the broad promotion on the part of the FAO [2014], in particular among the less developed countries, which, as we could assume, are most interested in achieving the sustainable development goals [Milder et al. 2012], these countries do not see any real opportunities in this development path as they primarily focus to ensure their food security. Thus, currently, most interested in the real implementation of the concept of sustainable agriculture based on intensification are the developed countries facing the food overproduction. These countries see in this concept a way of development, which is more just, in social and intergenerational terms.

With regard to these countries, based on foresight studies, the factors have been identified which will be responsible for the increased importance of the concept of non-industrial sustainable intensification of agriculture. In total, the experts participating in the study indicated 12 factors determining the development (Figure II.4).

Figure II.4. Assessment of factors responsible for increased importance of the concept of non-industrial sustainable intensification of agriculture



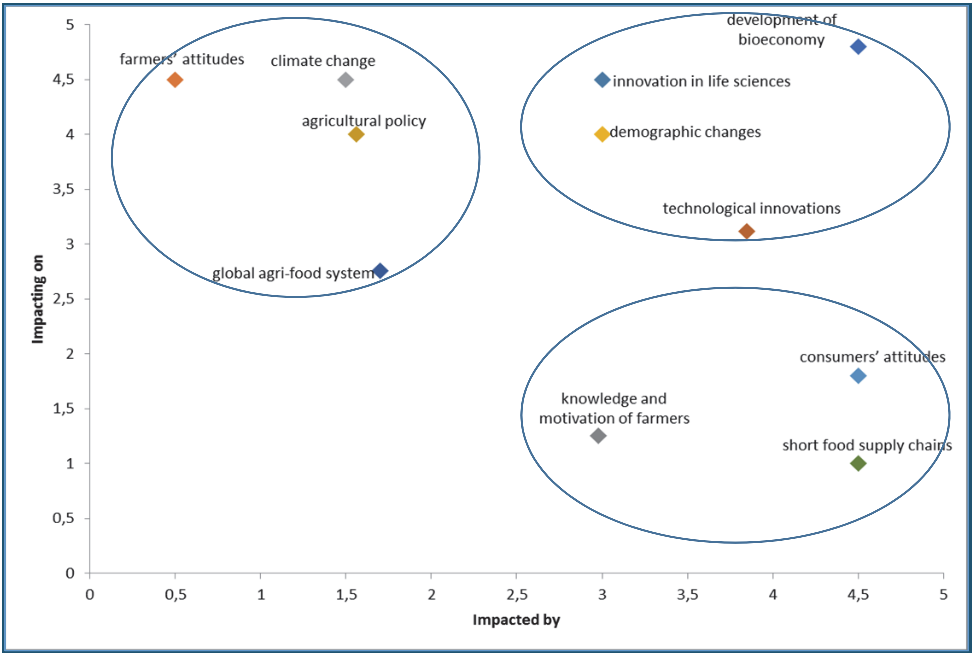
Source: own study based on the foresight study.

Two of these factors have negative vectors, so they are the development restraints. These are global agri-food systems managed by international corporations and farmers' attitudes. In the five-point scale, the negative impact of international corporations was rated at 3.4 points, which indicates that such a development model, highlighting, *inter alia*, the local scale of action, would be a serious threat to the interests of such structures. As a result, they would seek to preserve the *status quo* and maintain their dominance on many markets, by negating benefits and indicating the risks entailed by this way of development. A surprising result is the equally high rating (-3.8) of the impact of farmers' attitudes, the more than the positive factor, i.e. the knowledge and motivation of farmers has also been identified. This result can be explained by conservative attitudes of farmers who, admittedly, are willing to take risk resulting from the implementation of innovation, but if, e.g. the model of agroecologic intensification was introduced, they would consider it as a too radical revolution and thus would seek to reject it.

Among the factors potentially likely to have a positive impact on the development of the concept of industrial sustainable intensification, the strongest impact was that of the issues of demographic change (4.8 points out of 5), climate change (4.6 points out of 5), innovation in life sciences (4.2 points out of 5) and diffusion technology (3.9 points out of 5). At the same time, the institutional factor in a form of the agricultural policy oriented towards greening (in the European Union, in the USA and in other developed countries) will also play an important role, according to the experts (4 points out of 5).

The next part of the study determined the degree of interactions among the individual factors, using the cross-impact analysis (Figure II.5).

Figure II.5. Degree of mutual impacts of the factors responsible for increased importance of the concept of non-industrial sustainable intensification of agriculture



Source: own study based on the foresight study.

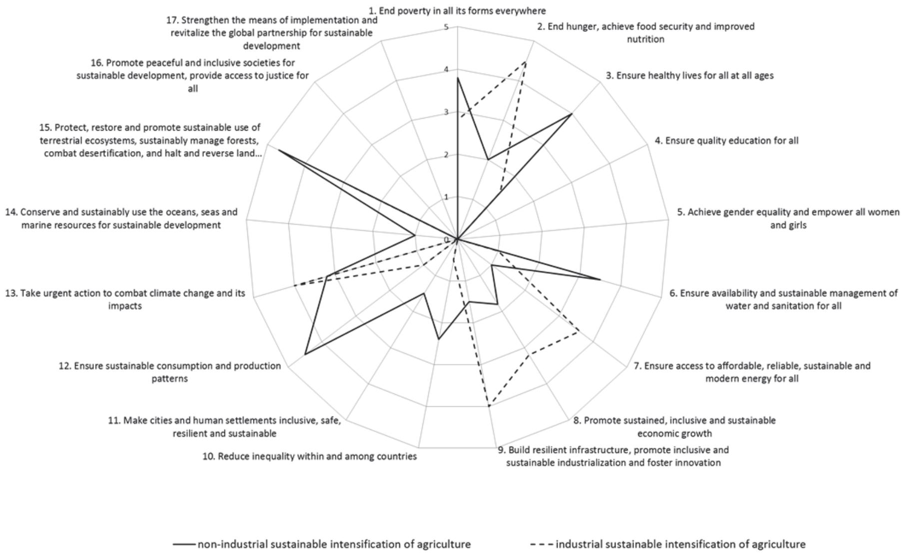
Three groups of factors have been identified based on the experts' indications. The first group brings together factors with a high impact potential, which, at the same time, are not much susceptible to impact. They include climate change, demographic changes, global agri-food system and agricultural policy. It can be considered that they are global factors (also the agricultural policy due to the fact that despite its regional nature it is pursued in global conditions). The second group brings together factors that are strongly susceptible to the impact of other factors, but do not have a strong impact themselves. This group consists of consumers' attitudes, knowledge and motivation of farmers and local supply chains. It can be noted that, unlike the first group, the factors of this group are local in nature and are characterised by considerable variability over time. The third group brings together factors with a high potential for causality, i.e. factors that exert a strong impact and are also strongly impacted by others. This group includes factors strongly linked to the creation, diffusion and use of knowledge, i.e. innovation in life sciences, technological innovations and development of bioeconomy. Bearing in mind the need for the real implementation of the concept of non-industrial sustainable intensification, particular attention should be given to the factors in groups 2 and 3, while aiming at the transition of, in particular, human factors (farmers and consumers) to group 3. This transition would allow to give the causal power to the factors responsible for the creation of demand for and supply of the products of the new agricultural system.

The experts participating in the study also assessed the impact of the industrial and non-industrial sustainable intensification of agriculture on achieving the goals of the Agenda for Sustainable Development 2030. The Agenda adopted by the UN leaders in 2015 sets out an ambitious plan to improve the lives of people in every part of the world. This Agenda is of universal, inclusive and indivisible nature and is a call for action on the part of all countries, irrespective of their level of development. The implementation of its objectives is: to eliminate poverty and hunger in all forms and aspects; to protect the planet from degradation; to take urgent action on climate change so that it can serve the needs of the present and the future generations; to ensure that all people can have a prosperous and satisfying life; to ensure that economic, social and technological progress is in line with nature; to promote peaceful, just and inclusive society, free from fear and violence, and; to mobilise resources to implement the objectives adopted. The Agenda includes 17 sustainable development goals, which were presented as "integrated and indivisible, global in their nature and universal" [OECD 2017].

With regard to the agri-food sector, the literature on the sustainable development goals criticises mainly the hegemony of corporate and political power interested in maintaining the economic growth, as well as the incapacity or aversion of farmers and consumers to counteract these trends [Clapp and Scott 2018]. As critically assessed by Helen Kopnina [2016], achieving the goals of the Agenda will not lead to the greater social equality and economic prosperity, but to the greater spread of unsustainable production and consumption, continued economic growth, as well as the population growth, which will result in further negative environmental pressure. The author argues that the anthropocentric, not environmental, nature of the considerations on sustainable development is responsible for the progressive unsustainability.

In the study, the experts agreed on positions which of 17 sustainable development goals included in the Agenda and to what extent will be pursued by two ways of sustainable intensification of agriculture (Figure II.6).

Figure II.6. Assessment of the impact of the industrial and non-industrial sustainable intensification of agriculture on achieving the goals of the Agenda for Sustainable Development



Source: own study based on the foresight study.

The results of the study showed that in the experts' opinion the industrial path could contribute more to achieving Goal 2 related to ending hunger and achieving food security (4.5 points out of 5) and Goal 7 related to ensuring access to affordable, reliable, sustainable and modern energy for all (3.6 points out of 5). The alternative path obtained low ratings for these goals, 2 points and 1 point, respectively. This indicates that the experts do not see non-industrial intensification as sufficient to meet the livelihood needs of people in the world. The industrial path obtained two more high ratings. They apply to Goal 9 related to building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation (4 points out of 5) and Goal 13 related to taking urgent action to combat climate change and its impacts (4 points out of 5). The justification for such ratings is the strong linkage between the industrial path and the existing model of the global agri-food system and the role played in it by international corporations and policymakers creating the development policy.

Table II.2. Opportunities and risks determining the sustainable agricultural development based on non-industrial intensification

Opportunities	Risks
▪ Inevitable demographic changes. ▪ Increasingly noticeable climate change. ▪ Progressive environmental degradation. ▪ Increasing pressure on the high--quality food production. ▪ Increasing lack of consumer consent to negative externalities of agriculture. ▪ Development of knowledge and intensified diffusion of innovation in life sciences. ▪ Implementation of the bioeconomy concept. ▪ Intensified interdisciplinary scientific debate leading to coherent conclusions. ▪ Agrarian structure with the domination of family farms.	▪ Lack of knowledge on alternative intensification and understanding of this concept. ▪ Farmers' resistance against change and willingness to pursue activity in its current form. ▪ Lack of adequate agricultural policy. ▪ Immaturity of local communities to cooperate in implementing the assumptions of broadly understood intensification. ▪ Negation on the part of global corporations proposing other solutions. ▪ Rising food prices reducing social support. ▪ Lack of immediate effects determining the assessment of actions taken.

Source: own study.

The experts also reached consensus as to the impact of the development of sustainable agriculture intensified agroecologically on the goals of the Agenda. They indicated as many as 6 objectives that could be supported by this way of development of agriculture. The strongest impact has been identified with regard to Goal 15 related to protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, and halting and reversing land degradation and halting biodiversity loss (4.7 points out of 5). The second environmental goal is Goal 13, demanding to take urgent action to combat climate change and its impacts (3.2 points out of 5). This is the result of a direct link of these goals with the assumptions of intensifying agriculture through the growth of natural capital. In the social context, non-industrial intensification affects the achievement of three goals. These are: Goal 1 – end poverty in all its forms everywhere (3.8 points out of 5), Goal 3 – ensure healthy lives and promote well-being for all at all ages (4 points out of 5) and Goal 6 – ensure availability and sustainable management of water and sanitation for all

(3.5 points out of 5). In the economic perspective, a significant impact (4.5 points out of 5) has been identified with regard to Goal 12 – ensure sustainable consumption and production patterns. The analysis carried out confirmed that the non-industrial intensification of agriculture could contribute to achieving the goals of the Agenda 2030 to a greater extent than the industrial intensification. At the same time, the proven impact on the goals related to 3 main development perspectives shows that the non-industrial path is more sustainable.

On the basis of the analyses carried out, the opportunities and risks determining the sustainable development of agriculture based on non-industrial intensification have been identified. They are presented in Table II.2.

***

The up-to-day development path of agriculture had accomplished its basic task, which is to ensure food security to the growing human population. One should be aware, that any change in the current development path concerns the existence of humanity. The question then arises whether to change anything. The answer is unambiguous. Change is necessary because continuing the current path leads to self-degradation. Thus, it is indisputable, that it must be changed. Which way to choose though? While industrial sustainable intensification of agriculture is an evolutionary continuation of the existing agricultural model, its alternative, non-industrial intensification, is of the revolutionary nature. It can, therefore, be the basis for the third green revolution in agriculture. Like each revolutionary idea, as for now it can be considered only as such category, it will bring chaos, misunderstanding and possible distortions, associated with the break of institutional ties and disorder of global balances, not only in the agri-food sector. The foundation of possible transformations will be the return to the roots of agriculture strengthened by the modern knowledge and manifesting itself by replacing the primacy of anthropocentric processes with the primacy of ecocentric processes.

But before this happens, the very concept of the alternative path, presented here as agrobiologic, ecologic, sustainable or agroecologic intensification, must be further developed. This requires further conceptual work to achieve a consensus among various stakeholders as to the assumptions of the chosen path, as well as the adequate operationalisation allowing to assess the adopted solutions.

The redirection of the path of the agricultural development rises also many questions, answers to which seem to be a pre-condition for implementation of real solutions and visible changes. There are a lot of questions to be answered. From the narrow – production perspective there is a big question about how to balance the production factors engagement in the agroecological system and what will be the role of the substitution in such induced development. From the wider – governance perspective there is a general question about the role of particular stakeholders of such complex system, especially farmers, scientists and consumers, especially who will take the lead role. Answering these questions today seems to be fraught with significant cognitive error and constitutes material for separate studies. However, it requires above all further interdisciplinary research.

Thus the uncertainty related to implementing the non-industrial development path of agriculture implies a need for interdisciplinary studies, which, by assumption, should not be global, as they have been so far, but they should focus on the regional and local perspective, which results directly from another revolutionary assumption of non-industrial sustainable intensification of agriculture – an assumption related to the localness of agroecosystems.

The final question is whether, and if so, to what extent non-industrial sustainable intensification of agriculture is likely to be implemented and developed as a really utilised concept. Taking into account the factors identified as the opportunities of its development, the answer must be affirmative. Yes, this way of development of agriculture is not only real, but seems inevitable. In the long run, its stages will be probably closer to the hype cycle model by Gartner than to the innovation diffusion curve described by Rogers.

CHAPTER III

AGRICULTURE PRODUCTION POTENTIAL AND FARMS' ENVIRONMENTAL SUSTAINABILITY – REGIONAL CONVERGENCE OR DIVERGENCE?

In the last three decades, the world economic and agricultural literature has presented a variety of approaches to the issue of sustainable development. The idea of sustainable development essentially boils down to conservation of the environment and natural resources for the future generations in a condition that is not worse than it was for the current generation. Implementation of this idea mainly requires changes in the consumption patterns, changes in the value system and the introduction of such a system of management where pressure on the environment does not exceed its capacity [WCED 1987].

The implementation of the sustainable development principles is particularly important in agriculture, which has a strong impact on the natural environment. The specificity of agriculture are side effects of conducted agricultural activities, which are both positive and negative externalities. In the second case, the consequence of agricultural practices is constituted by the irreversible degradation of valuable natural resources, including the ones in the form of reduction or loss of soil productive potential. According to the idea of sustainable development, every individual should feel obliged to protect the natural environment and apply principles of rational management of natural resources [Woś and Zegar 2002]. Unfortunately, externalities generally are not taken into consideration in the microeconomic criterion of making decisions by agricultural producers. Consequently, this leads to a discrepancy between the economic entity's goal and the goal of the public [Zegar 2010].

Different benefits are the attributes of sustainable agriculture model, e.g. production (allowing to ensure food security), economic (pertaining to income category level), environmental (approaching to reduce the pressure of agriculture on the natural environment), as well as social ones (seeking to maintain the vitality of rural areas, ensuring safe food) [Zegar 2005]. An important part is the rational use of agricultural production space and to maintain the production potential of soil [Krasowicz 2005].

Sustainable agriculture should be considered at the different levels of vertical order, paying particular attention to microeconomic level of sustainability – the farm's level [Wrzaszcz and Zegar 2016]. Economic objectives are the most important in the case of farms, while others – social and environmental goals – should be achieved simultaneously, according to sustainability theory. Taking into consideration limited environmental resources, the superiority of this system should be the benchmark for the social and economic activity of farmers. Maintaining natural resources and their rational use is leading to this concept [Adamowicz 2016]. These are scientific conditions of agricultural activity, however, in practice, agricultural producers (as well as other groups, e.g. policymakers), often do not take them into account in their decisions, whereas microeconomic interest is superior.

The European and national policy, changing consumer preferences and growing environmental awareness of the society have brought about the need to assess agricultural activity in terms of its sustainability. This evaluation should be carried out at various levels, i.e. from the global to the local one. The global approach is focused on world supply of food, maintenance of an adequate area of arable land, determining legal regulations on trade in agricultural products and minimising the impact of agriculture on climate. The continental and national approach is interpreted similarly. The quality of agricultural practices is also analysed at the regional, the farm and the field level. Each level is equally important and the effects (negative and positive ones) generated at one level are expressed at another [Loon et al. 2005].

In view of the above, the need for defining development direction of farm arises, whether it is sustainable development, or rather industrial one. As pointed out in the literature, agriculture development has found itself at the crossroads and those two main paths are designated by the model of industrial agriculture (that is characterised by intensification of agriculture, concentration of the production potential and production, specialization of agricultural holdings and entire regions, commercialisation and, nowadays financialisation issue) and the model of sustainable agriculture (that takes into consideration not only production and economic outcomes, but also social and environmental issues) [Zegar and Wrzaszcz 2017]. Dual development of the Polish agriculture was observed so far and parallel development of those two models is the most likely in the near future [Henisz-Matuszczak 2007; Wrzaszcz 2014]. In accordance with the above, the part of farms will apply agricultural production methods directed towards high economic efficiency, while respecting only basic (mandatory) environmental protection requirements. In the case of others, agricultural production will be more environmentally friendly, generating diversified profits, not only for farmers, but also for society and nature. The question concerns the proportion between sustainable and industrial farms – which farms' group will be dominating and supported.

The main environmental requirement of farmers' activity (micro level analysis of agriculture sustainability) is to maintain soil productive potential, which is one of the basic elements of the natural environment used in agriculture. The main principle allowing conducting agricultural production with respect to natural resources is suitable crop rotation and crop fertilization, adapted to the local environmental conditions. This is the basic principle of sustainable agricultural production. Crop rotation – which can be defined as a rational sequence of cultivated crops, considering their diverse needs concerning position in crop rotation – comprises the canon of traditional agrotechnics [Manteuffel 1981, p. 310]. Proper crop rotation and fertilization should ensure a positive balance of soil organic matter, recognized as the basic principles of management in agriculture [Kuś et al. 2008, p. 13]. Positive balance is the necessary condition for ensuring appropriate productivity of cultivated crops and their supply. Organic matter and its conversion into humus, plays the main role in creating and maintaining soil fertility at a high level, i.e. favourable for crop growth and yields, their physical, chemical and biological properties. Humus content in soil leads to obtaining crops of high quality and increasing yield level.

Taking into consideration the above issues, sustainability of farms and agriculture correspond with production potential of agriculture. Possibilities of agriculture sustainability are determined by production potential elements, e.g. agricultural land area and soil quality (those elements correspond with crop rotation possibilities), livestock density (agricultural production orientation establishes fertilization planning and soil fertility maintenance), possible labour inputs (sustainable farms' organization is more labour intensive than industrial one, that is the outcome of partial substitution of limited chemical means of production use). At the farm level, production organization (that is significantly determined by production potential of the farm) results in its farming type, describing production profile and specialization level. Against this background, the analysis of agriculture production potential changes constitutes the important point of reference to sustainability evaluation.

Regional dimension is of particular importance when assessing sustainability of farms and agriculture. The variety of scientific studies indicate the need for economic and agricultural research in regional terms [e.g. Adamowicz and Szepeluk 2018; Smędzik-Ambroży 2015]. Significant diversification of agriculture, both at the level of Poland (national consideration), as well as Europe (international approach) mandates to regional studies conducting. Regional diversity of agriculture is related to the number of issues, including agriculture sustainability. The important issue is to define the scale of diversification and progressive changes in this scope, in other words, the phenomenon of regional convergence or divergence. Taking into consideration the scale of farms' support under the Common Agricultural Policy (CAP) in the last decade (2005-2016), the question arises, whether agriculture in the regions of Poland aligns in terms of environmental pressure or whether the regions develop independently from each other (areas with a higher level of development had a greater potential to faster development).

Poland's accession to the European Union in 2004 resulted in introduction of many programmes into agricultural sector to support the widely understood development. The orientation of the agricultural policy towards the sustainable development of agriculture and rural areas has been associated with implementing a series of measures and instruments facilitating farms' transformation. In the case of Poland, these instruments have been mainly implemented since 2005. Those instruments, on the one hand, promoted farms' reorganization towards environmental direction, on the other, improved their economic situation, which largely is determined by their innovation and competitiveness [Ministry of Agriculture and Rural Development 2018]. Now, after a dozen years from Poland's accession to the European Union, there is a need to identify the current sustainability effects of farms. Identification and evaluation of progress in the field of environmental sustainability of agricultural holdings is particularly important in the context of the present and future agricultural policy. There is a need for monitoring the policy results, that should be the basis for recommendations and suggestions to future agricultural policy development. The importance of these research indirectly indicates also literature review, because there is no scientific and political clarification in which direction the Polish farms should be supported and developed – sustainable or industrial one.

The aim of the paper was evaluation of regional convergence (divergence) of agriculture in the scope of production potential and environmental sustainability. The spatial diversity of family farms was established as the basis of convergence (divergence) process indication. Central Statistical Office (CSO)[10] data for 2005, 2007 and 2016 were used to analyse the period of Poland's membership in the European Union. The main research results were presented, concerning farms' development direction in regional perspective.

1. Regional convergence issue

The problem of sustainability measurement increases in the context of the need for monitoring of changes in terms of regional (voivodeships) and periodic approach. Agriculture in the regions varies significantly, including sustainability phenomenon [GUS 2013]. There is, however, a need to determine whether this interregional diversity deepens over time, or do the regions become similar.

[10] CSO – in Polish: Główny Urząd Statystyczny (GUS) [http://stat.gov.pl/en/].

Hence, determination of regional convergence or divergence of farms' environmental sustainability is very important.

The concept of regional convergence/divergence have been widely defined in the literature [e.g. Malaga and Kliber 2007]. Convergence in the macroeconomy means the process of aligning the values of main macroeconomic variables between countries or regions with different baseline [Trojak and Tokarski 2013]. The study of convergence phenomenon allows to determine whether the analysed regions, which differ in the level of selected variables at the starting moment, become similar to each other over time, or does the differentiation deepens between them. Making up for the distance to regions with the best results means the convergence process, while its increase proves divergence process.

In the literature there are two commonly-used measure of convergence: σ-convergence and β-convergence [Malaga and Kliber 2007]. Sigma (σ) convergence occurs when the diversity of a variable between regions decreases over time, and beta (β) convergence occurs when we are dealing with declining dependency between the average level of the analysed variable and initial level of the variable. Usually, the σ-convergence is measured by the change in the standard deviation of the analysed variable, as evidenced by its decreasing value with the passage of time. The process of σ-convergence can also be tested by changing variation coefficients (based on standard deviation, average deviation and quartile deviation), which are relative measures of differentiation [Trojak and Tokarski 2013]. Variation coefficient is the quotient of the absolute measure of variation to respective average values [Zeliaś 2000].

2. Research methodology

The Farm Structure Survey (FSS) data of CSO were used in the research[11]. The analysis concerns all individual agricultural holdings with at least one hectare (1 ha) of agricultural land maintained in Good Agricultural and Environmental Conditions (GAEC) in 2005, 2007 and 2016. These data were collected on the basis of uniform methodology that allowed to investigate the direction in which tends the Polish agriculture in the regions with regard to environmental sustainability. According to NUTS 2 division, 16 voivodeships stand out and those administrative units were analysed in the study[12].

The Farm Structure Survey research is carried out in individual European Union countries and results are finally aggregated in EUROSTAT databases. The

[11] Initial calculations were prepared in cooperation with the Statistical Office in Olsztyn for the purposes of the Multi-Annual Programme 2015-2019 "The Polish and the EU agricultures 2020+. Challenges, chances, threats, proposals" realisation.
[12] The term: voivodeships and regions were used interchangeably in this chapter.

proposed use of data for farms' environmental sustainability measurement and convergence evaluation can be applied to other countries to conduct comparative analyses.

Agriculture and an average farms' characteristics, which concerned economic and production potential, used in the research were the following: agricultural land area (ha), labour input (expressed in Annual Work Units – AWU[13]), livestock population (Livestock Units – LU[14]), the value of standard output (thousand EUR)[15] and standard gross margin (European Size Units – ESU)[16].

Based on selected indicators, farms' environmental sustainability was established. Presented indicators are not, however, a universal list, but they bring a measurable range of farms' environmental sustainability with arable land cultivation, adapted to the substantive criteria and available official national statistical data. Each of the indicators was calculated at the farm's level. The indicators allowed to determine the crop diversity, stocking density as well as the level of fertilization and soil quality[17]. The indicators are stimulants, destimulants or nominants, with varied significance in the context of environmental sustainability. As the point of reference in farms' sustainability evaluation, threshold values were established. The following indicators have been applied[18]:

---

[13] 1 AWU is equivalent to labour inputs amounting to 2,120 hours a year; this is equal to AWU used usually in statistics and farm accountancy system Farm Accountancy Data Network.

[14] 1 LU is a conventional unit of farm livestock with a mass of 500 kg. See tables of conversion coefficient for livestock from physical units to livestock units [GUS 2013].

[15] Standard output is the mean of 5 years of the value of production corresponding to the average situation in the region. Total standard output of farms is the sum of the values obtained for each agricultural activity on the farm by multiplying the coefficients of the standard output for a given activity and the number of hectares or number of livestock [Goraj et al. 2012]. It is an economic category that allows for comparing the volume of production, while offsetting the impact of price fluctuations in regional and temporal terms. In the research, 2013 standard output indicators were used (based on the average values for the period of 2011-2015).

[16] Sum of standard gross margins (SGM) – the difference between output and specific (direct) costs of all activities occurring on the farm – indicates the economic size of the farm, otherwise the productive potential of the farm. 1 ESU is equivalent to EUR 1,200. The standard gross margin is the average gross margin by region. Standard gross margin on a particular crop or livestock is a standard (average of three years in a particular region) value of production obtained from one hectare or from one livestock less the standard direct costs necessary to produce.
There were used 2004 standard gross margin indicators – the last SGM calculated indicators, used in FADN. In subsequent years, there was used FADN farms' typology based on the coefficients of standard output.

[17] In the case of fertilization, 2007 and 2016 data were used. In 2005, the scope of FSS research did not take into account fertilization issue.

[18] Rich literature reference to specified indicators were presented in e.g. [Wrzaszcz 2018, Harasim 2014].

- The share of cereals in crop structure on arable land determines the correctness of crop rotation and the degree of agrocenose biodiversity[19]. The share of cereals should not exceed 2/3 (the reference value) of the area.
- The number of crop groups cultivated on arable land is a complementary indicator to the above one that indicates the possibilities of crop selection and rotation, which increases the guarantee of limiting the development of pest populations, reducing weeds and losses. At least 3 crop groups should be cultivated, out of the following: cereals, legumes and papilionaceous, root crops, industrial crops, grasses on arable land, other crops.
- The index of winter vegetation cover on arable land – is a synthetic indicator for the assessment of land resources and natural resources protection, the ecosystem balance and the degree of implementation of sustainable production system in agriculture. Vegetation cover should be at least 1/3 of the crop area.
- Stocking density on agricultural land – provides information about the level of livestock intensity and also indicates the scale of the environmental impact of natural fertilizer. Stocking density should not exceed 2 LU/ha.
- Balance of soil organic matter on arable land – a positive result reflects good crop rotation and systematic enrichment of the soil with humus. The reference value should be positive, above zero[20].
- Gross balance of nitrogen (N), phosphorus (P) and potassium (K) in the soil – is a very important source of information on the impact of agriculture on environmental conditions, which is a consequence of agricultural production intensity and efficiency measured by the level of mineral fertilization, stocking density and crop yields. Optimal level of NPK balance is regionally diversified [Kopiński 2017].

On the basis of the adopted indicators of environmental sustainability and threshold values assigned to them, farms' percentage with environmental criteria fulfilment was established in each voivodeship. The higher percentage of farms that meet sustainability criteria, the more favourable evaluation of this phenomenon is. Sustainable farms' percentage should be treated as a stimulant of this phenomenon.

---

[19] *One of the most important factors affecting agroecosystem biodiversity is the way of agricultural management and land use* [Feledyn-Szewczyk 2014, p. 16]. The diversity of cultivated crops – species biodiversity, determines the capabilities of crop rotation [Feledyn-Szewczyk 2015]. The cultivation of several crop species results in improvement of soil quality, including the diversity of soil organisms.

[20] Methodology for the calculation of soil organic matter balance was presented in publications [Wrzaszcz 2009, Wrzaszcz 2010, GUS 2013].

Then, to synthetically assess the changes that have been made in the environmental diversity of agricultural holdings, normalization of variables was carried out (Formula 1). Normalized values enabled the synthetic indicator construction of farms' environmental sustainability in various voivodeships.

In connection with the fact that sustainability indicators were varied in terms of their importance, weights were assigned, that were used in calculation of sustainability synthetic indicator, in accordance with Formula 2. The studies assume that soil organic matter and nitrogen balances are the most important, thus the weight amounting to 2 was used. In the case of other indicators, the weight was 1 (for crop diversification indicator based on cereal and crop groups criterion, winter crops indicator, balance of phosphorous and potassium). However, due to the lack of diversity of the regions in terms of stocking density, this indicator was omitted in the synthetic indicator. The higher values of synthetic indicator pointed out higher level of farms' environmental sustainability in the region.

The convergence process of farms' environmental sustainability was verified on the basis of differences in variation indicators values of individual variables (V_j; Formula 3), based on the standard, average and quartile deviation (V_{SD}, V_{AD} i V_{QD}). Variation coefficients allow diversification assessment of the same population in terms of several different features and homogeneity degree of analysed population. It is assumed that if variation coefficient does not exceed 10%, the feature exhibits statistically insignificant diversity [Zeliaś 2000]. Variation coefficients were calculated respectively for each variable in the analysed years. The reduction of variation indicator value with the passage of time informs about convergence process, while its increase confirms divergence phenomenon.

Using these formulas, the variability of farms' production potential in voivodeships was also assessed. In the case of synthetic indicator of farms' production potential, weights were not used to individual components (agricultural area, labour input, livestock density, standard output value). Each element was equally important in the research.

$$(1)\ x'_{ij} = \frac{x_{ij}}{\max(x_j)}$$

$$(2)\ S = \frac{\sum_{j=1}^{m} x'_{ij} * w_j}{\sum_{j=1}^{m} w_j}$$

$$(3)\ V_{jk} = \frac{\overline{x}_j}{D_{jk}} * 100\%$$

x_{ij} – value of the *j* variable in *i* object (voivodeship), were $i = 1, ..., n$, $j = 1, ..., m$; $\max(x_j)$ – maximum value of *j* variable between voivodeships; w_j – weight for *j* variable (concerns sustainability indicators); S – synthetic indicator; $\overline{x}_j$ – average value of *j* variable; D_{jk} – deviation of *j* variable, *k* – deviation: standard, average, quartile; V_{jk} – variation indicator of *j* variable, with *k* deviation.

3. Agriculture production and economic potential

Agriculture in Poland has changed significantly over the last several years (Table III.1, Figure III.1). These changes concerned mainly farms' number, their potential and production profile. In 2016, there were 1.4 million individual farms. The number of farms and labour inputs decreased by almost 1/5 in comparison to 2005 (1.7 million), that indicated the withdrawal of many farmers from this economic activity. Simultaneously, the area of agricultural land in good agricultural condition was around 13 million ha in 2005 and 2016. The area in absolute terms increased by 121 thousand ha in the period, which was the result of the introduced commitments relating to the receipt of direct payments by maintaining land in good agricultural condition. Before Poland's accession to the European Union, this land was not used and partially set aside. The legal obligation to restore land use or to maintain it in a form of fallow land (i.e. land maintained in good agricultural condition) has been translated into the environmental-oriented agricultural practices of their users. Farmers interested in receiving direct payments were required to follow certain agricultural practices on cultivated agricultural land.

At the same time, human labour inputs in agriculture have been significantly reduced, by 1/5 (from 2.04 to 1.62 million AWU). These changes resulted mainly from reduction in the number of farms. Another important factor was the changing agricultural production technology, resulting from farms' modernization. The observed substitution of human labour on farms for objectified labour (costly investments or changes in the agricultural production technology by simplification, automation and mechanization of this process) stemmed, to a significant extent, from the support for agriculture under rural development programmes covering co-financing of costly investments (including improvements in building equipment and the purchase of agricultural equipment).

In the analysed period, a decrease in the livestock population was observed (by 8%, from 6.4 to 5.9 million LU). Simultaneously, during the analysed period, many farms resigned from livestock production – the number of farms with livestock decreased by 43%. This process had a negative environmental impact, due to reduction in the amount of natural fertilizers of livestock origin and progressive dependence of agricultural production on industrial means of agricultural production (mineral and chemical fertilizers) [Wrzaszcz 2018]. Reduction of livestock herd or its liquidation were primarily dictated by market impetus (that determined profitability reduction), as well as legal requirements of livestock production. Those processes interacted with both the prices of agricultural means of production (industrial feed prices), as well as the sale prices of agricultural products. In addition, the requirements of the European Union with regard to animal welfare required to take the investment activities, which constituted a significant financial charge for farms, in particular small units [see e.g. Strategia odbudowy i rozwoju… 2013; Skarżyńska 2017; Trajer and Krzyżanowska 2014].

The measurable determinant of farms' economic potential is standard output and standard gross margin. In the case of the first category, an increase of nearly 5% has been reported in the analysed period while the second one decreased by 7%. Discrepancies between these categories result from significant impact of direct costs on agricultural activity. This increase was particularly related to the prices of industrial means of agricultural production, including mineral fertilizers, crop protection products, livestock feedstuffs and feed additives. In addition, in the analysed period the dependence of agricultural production on external (industrial) means of production increased, as the consequence of the more and more common separation between crop and livestock production at the farm level.

Having regard to the regional aspect, agriculture productive potential in individual voivodeships significantly differed from each other in terms of its considered components. Very high values of variation indicators (V) pointed out production potential diversification (Table III.1). In both 2005 and 2016, Mazowieckie was the region with the largest number of agricultural holdings, area of agricultural land, the scale of livestock production, and finally also the values of generated standard output. During the period generally the differentiation between the regions in this regard had not changed, except for the size of livestock population. The higher value of the regional diversity indicator in this respect pointed to outlining the trends of regional divergence.

The scale of change of production potential components in the regions was varied (Figure III.1). In all voivodeships, decrease in farms' number was reported. However, the voivodeships of Southern and Western Poland are the area with the most significant decrease of farms (Śląskie – the decrease of 39%, Lubuskie – of 30%, followed by: Małopolskie, Dolnośląskie, Opolskie and Podkarpackie). These declines can be linked to two phenomena. On the one hand, it occurs in the area of "weak" agriculture (the example of Małopolskie or Podkarpackie voivodeships) that indicates farmers' resignation farm agricultural activity because of difficult production conditions and low outcomes. However, in the case of the Western regions (Śląskie or Lubuskie), these declines were probably associated with a progressive specialization of the part of farms, thereby withdrawal of others from the market, who do not have the ability for economic competition.

Table III.1. Agriculture production and economic potential in voivodeships and its diversity (2005 and 2016)[a]

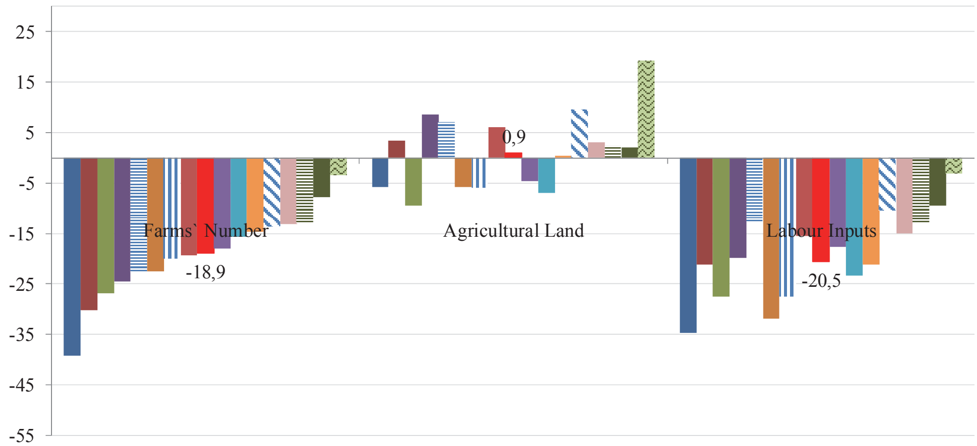
No.	Specification	F_NR (thousand)	AL in GAEC (thousand ha)	LI (thousand AWU)	LD (thousand LU)	Farms with livestock (thousand)	SO (mln EUR)
1	**2005 Poland**	**1,723.9**	**13,060.6**	**2,035.2**	**6,430.3**	**1,247.6**	**20,824.1**
2	Dolnośląskie	71.4	698.6	64.2	140.5	39.8	895.0
3	Kujawsko-pomorskie	72.7	908.1	98.3	522.4	56.9	1,715.7
4	Lubelskie	210.5	1,365.2	256.9	538.1	151.1	2,022.7
5	Lubuskie	28.3	332.0	25.7	94.6	16.7	416.4
6	Łódzkie	146.1	1,004.1	185.4	543.9	109.4	1,711.3
7	Małopolskie	190.4	587.2	220.5	322.1	153.3	1,003.7
8	Mazowieckie	258.4	1,947.6	318.9	1,018.0	170.4	3,405.3
9	Opolskie	35.0	355.0	37.7	148.5	26.6	563.1
10	Podkarpackie	170.6	581.9	182.7	233.4	135.4	834.4
11	Podlaskie	93.1	1,036.6	1170	705.5	67.7	1,559.3
12	Pomorskie	47.5	582.3	54.0	236.0	31.9	835.6
13	Śląskie	87.9	358.1	76.1	157.0	57.1	525.5
14	Świętokrzyskie	105.8	505.6	138.3	247.3	80.9	887.8
15	Warmińsko-mazurskie	44.0	772.8	55.2	443.9	32.8	1,026.8
16	Wielkopolskie	128.7	1,430.3	174.0	959.8	99.0	2,774.1
17	Zachodniopomorskie	33.4	595.2	30.2	119.2	18.6	652.8
18	V_{SD}	190.3	189.5	190.7	191.0	190.5	190.3
19	V_{AD}	91.9	91.4	93.0	95.5	91.0	94.4
20	V_{QD}	30.4	14.8	27.2	25.6	34.9	18.0
1	**2016 Poland**	**1,398.1**	**13,181.4**	**1,617.0**	**5,923.5**	**712.6**	**21,824.3**
2	Dolnośląskie	55.2	748.4	56.0	95.4	21.3	932.6
3	Kujawsko-pomorskie	63.2	929.7	85.8	471.3	33.4	1,759.2
4	Lubelskie	179.6	1,370.4	202.5	376.9	79.5	1,978.8
5	Lubuskie	19.7	343.3	20.3	101.0	7.7	466.2
6	Łódzkie	123.2	933.5	142.0	493.4	59.9	1,727.8
7	Małopolskie	139.3	532.0	159.9	190.5	88.4	851.0
8	Mazowieckie	211.9	1,857.4	262.7	1,106.6	93.7	3,796.8
9	Opolskie	26.4	385.1	30.3	119.0	12.9	585.9
10	Podkarpackie	132.1	548.5	124.4	118.5	85.1	673.9
11	Podlaskie	80.9	1,068.2	99.5	800.3	44.1	1,706.9
12	Pomorskie	38.3	617.3	45.7	208.3	18.8	835.2
13	Śląskie	53.4	337.6	49.7	127.4	28.1	490.1
14	Świętokrzyskie	84.7	475.7	100.2	160.3	48.8	773.4
15	Warmińsko-mazurskie	42.5	922.1	53.5	465.7	21.0	1,318.0
16	Wielkopolskie	118.7	1,460.2	157.7	992.0	60.3	3,193.5
17	Zachodniopomorskie	28.8	652.1	27.0	97.0	9.7	740.0
18	V_{SD}	190.4	189.4	190.6	192.8	190.5	190.8
19	V_{AD}	92.7	90.6	93.5	101.9	90.4	96.7
20	V_{QD}	27.2	17.3	28.4	26.9	34.9	19.8

[a] F_NR – number of farms; AL – agricultural land; LI – labour input in Annual Work Units; LD – livestock density on livestock farms (1 LU – the equivalent of 1 dairy cow); SO – standard output (an average five-year value from an agricultural activity), see: [Florianczyk et al. 2018]; coefficients of divergence (V) based on standard (V_{SD}), average (V_{AD}) and quartile deviation (V_{QD})

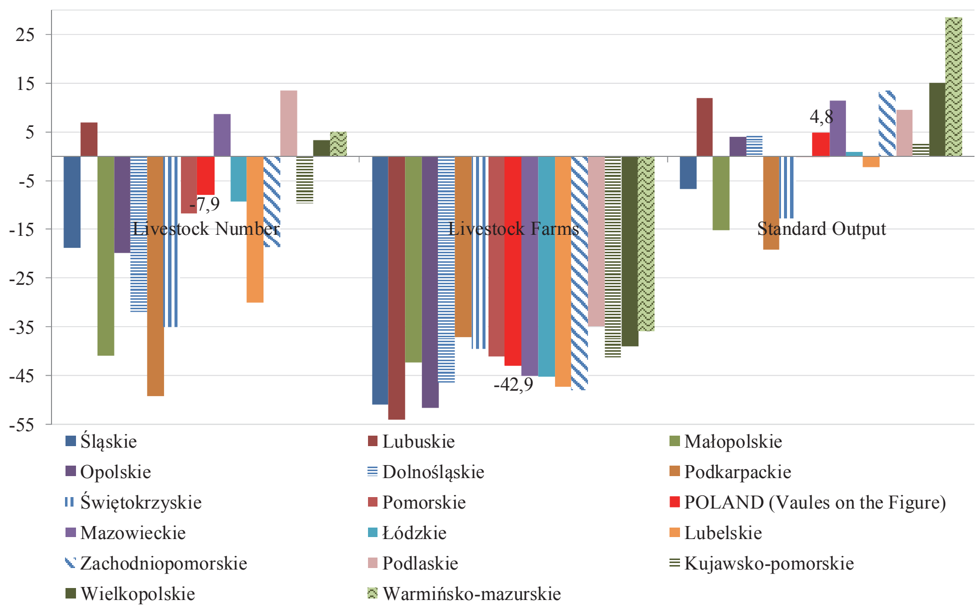
Source: own calculation based on data for 2005 and 2016 of CSO.

Figure III.1. The changes of agriculture production and economic potential in voivodeships in the period of 2005-2016 (%)

1a. Farms' number, agricultural land and labour inputs change



1b. Livestock number, livestock farms and standard output change



Source: own calculation based on data for 2005 and 2016 of CSO.

Changes in agricultural area in good agricultural and environmental conditions are an important issue. The area increase demonstrates the more effective use of land production potential, which had previously not been cultivated (as happened, for example, in Warmińsko-Mazurskie or Zachodniopomorskie). Simultaneously, in other regions, agricultural area decrease was observed, particularly in Małopolskie, Łódzkie or Świętokrzyskie, which informs about land allocation for non-agricultural purposes.

The fact of farms' withdrawal from livestock production is of particular concern. This process especially concerned Lubuskie, Opolskie or Śląskie (about the half of farms resigned from this production in those regions). There were also the areas, where livestock production specialization has developed by increasing production scale. These results confirmed the farms' polarization process. Farms, that had not been able to compete in this agricultural activity were reorganized and the same advantage of the "strongest" units strengthened.

In general, livestock population has been reduced in the majority of voivodeships. While those regions that specialize in livestock production, increased the scale of production. For example, Podlaskie – increase in livestock population of 13%, Mazowieckie – 9%, Lubuskie – 7% and Warmińsko-mazurskie and Wielkopolskie, respectively 5% and 3%. Based on the above percentages, it can be stated that regions directed towards milk production (cattle) increased the scale of livestock production more intensively than regions associated with granivores (pig and poultry).

These changes can be evaluated both in terms of economic and environmental issues. Regarding economic issues, farmers' withdrawal from livestock production (who previously ran a mixed agricultural production, based mainly on own feed) reduces the source of income. While the increase in the level of production specialization at the farms specialized in livestock production will improve their market position and then economic result. Taking into account the environmental issues, both the liquidation of livestock production as well as excessive growth of its intensity is associated with negative effects. The former case regards to greater challenges for farmers in proper crop fertilization (the lack of their own manure and need to purchase the appropriate amount of mineral fertilizers). And in the second case, higher specialization results in an increase in emissions of gases and odours, as well as the need of appropriate disposal of natural fertilizer surpluses (their storage and distribution, dependent on farm's own fertilization demand and sale possibilities), which is associated with organizational challenges.

Values on the Figure III.1 confirmed, that voivodeships developing livestock production recorded the largest increases in standard output. Those results indicated the livestock production importance in creation of economic account of the agricultural producer.

In the analysed period of 2005-2016, there were significant changes in the production and economic structure of farms (Figure III.2a). Taking into account farms' area of agricultural land, the share of the smallest farms with an area of 1-5 ha decreased (from 57% to 54%), while it substantially increased in the case of medium and large farms with an area of 25 ha and more, particularly those with an area of 50 ha. These confirmed the thesis of the progressive land concentration process on large farms, which gradually increase their production potential.

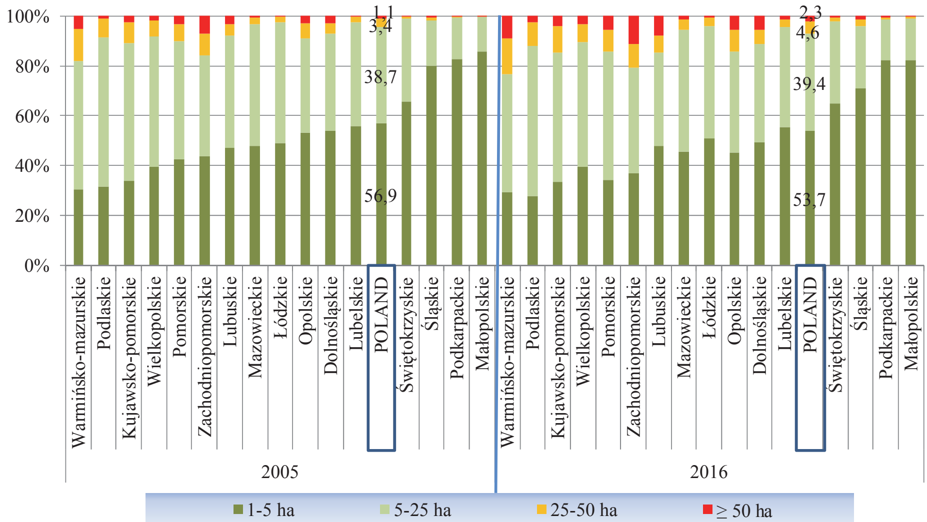
Area structural changes took place in all voivodeships. In the case of the Western regions (Zachodniopomorskie, Opolskie, Dolnośląskie), as well as Pomorskie and Śląskie, many of these small farms were liquidated during the period, and, at the same time, the largest farms grew, i.e. 50 ha and more. These changes indicated the purchase of the smallest agricultural holdings by those with larger production and economic capacity. As a result of significant structural changes, Zachodniopomorskie, Warmińsko-mazurskie and Lubuskie are the areas with the highest proportion of large farms, e.g. 50 ha and more (respectively in the regions: 11.3%, 8.9% and 7.6% in 2016).

The structure of farms' economic potential has also changed significantly (Figure III.2b). The share of very small farms (producing less than EUR 8 thousand) increased, which indirectly points to the fact that farms with the lowest economic potential resign from agricultural production. At the same time, the share of small (EUR 8-25 thousand) and medium-small (EUR 25-50 thousand) farms decreased in favour of large farms. The biggest changes applied to large farms (EUR 100 thousand and more), which accounted for only 1% of farms' population (in 2005), although their share increased to more than 2% (in 2016)[21]. The presented structures point to an increase in farms' percentage with the greater production and economic potential.

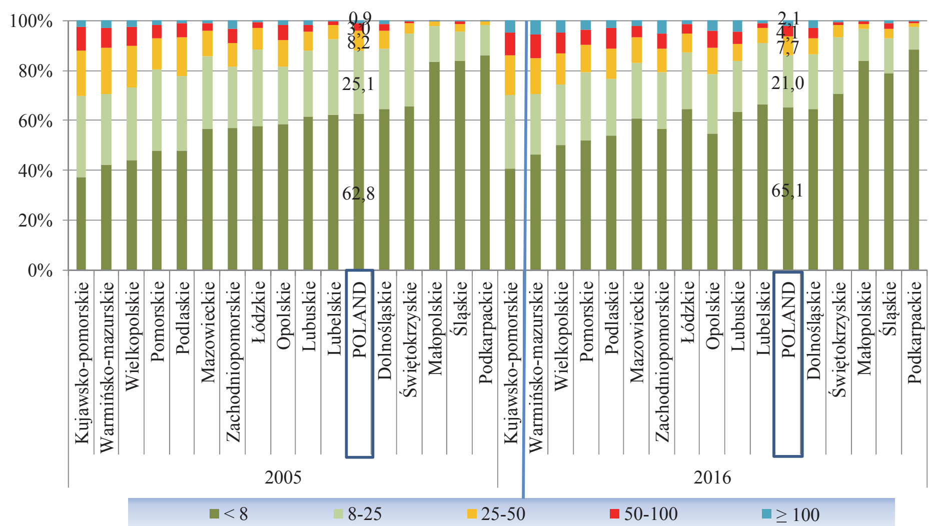
At the regional level, only in the case of two voivodeships, the percentage of small farms in economic significance dropped, e.g. in Opolskie and Śląskie. There are examples of the regions where there is a general decrease in the number of farms. The strongest polarization of farms in economic terms took place in the regions, where larger farms grew (with standard output EUR 50 thousand and more per farm). There are regions focused on livestock production, in particular cattle/milk production (Podlaskie, Warmińsko-mazurskie), as well as the Lubuskie (example of a region with pig production development).

[21] See methodology in: [Floriańczyk et al. 2018].

Figure III.2. Farms' structure according to production and economic potential
2a. Agricultural land in ha/farm in 2005 and 2016



2b. Standard output in thousand EUR/farm in 2005 and 2016



Source: own calculation based on data for 2005 and 2016 of CSO.

As indicated in Table III.2, the average individual farm in Poland is small, both in terms of agricultural land and generated standard agricultural output. Nevertheless, in the analysed period, the average farm significantly increased its area – by around 1/4 (from 7.6 to 9.4 ha), which resulted in an improvement in their economic potential – almost by 30% (from 12.1 to 15.6 thousand EUR, Figure III.3).

Having regard to the area of the average farm, the input intensity of human labour has decreased significantly in the analysed years (Table III.2). Farms with livestock production increased their scale (livestock population increased by 60% per average farm with livestock). These figures confirmed, on the one hand, the progressive process of farms' specialization oriented towards the livestock production and, on the other, point to the growing population of non-livestock farms where the livestock production was not the dominant production activity in the previous years [Wrzaszcz 2018]. In assessing the capacity of the average agricultural holding based on synthetic indicator of production potential, it can be considered comparable between 2005 and 2016 (value stood at 0.55 and 0.54 respectively).

Taking into account the regional division, farms significantly differed from each other in terms of production potential (variation standard coefficient of agriculture production potential amounted to 30% in 2005 and 32% in 2016). Warmińsko-mazurskie and Kujawsko-pomorskie voivodeships were characterised by the highest values of farm's production potential (Table III.2). At the opposite side, Podkarpackie, Małopolskie and Śląskie voivodeships were placed with the lowest production potential in the analysed years. Livestock population was a factor deeply differentiating farms between the regions (V_{SD_2005} = 53%, V_{SD_2016} = 60%), then agricultural area and standard output, while on the extreme of statistical significance was labour input variability.

During the period of 2005-2016, farms in the regions changed significantly in terms of production potential, although these changes took place with different pace and on different terms (Figure III.3). In general, the process of farms' extension was observed, which concerned their area and production volume. Farms focused on livestock production, in majority of the regions, the scale of this production increased (with the exception of Podkarpackie Voivodeship), usually maintaining or even reducing labour inputs per farm. These data confirmed the process of land and livestock production concentration, with accompanied increase in labour efficiency.

Taking into consideration the scale of individual elements of production potential changes in regional division, it can be concluded that converse relation between changes in farms' surfaces and labour inputs is observed, in the case of majority of the regions. In principle, farms are targeted at making investments in selected elements of agriculture production potential. Simultaneously, these figures confirmed more loose relationships between crop and livestock production at the farm level. The exception is Lubuskie Voivodeship, that stood out both in terms of the largest increments of surfaces and livestock herds. The presented values indicated, that changes in the value of standard output on the average farm in regional perspective are derivatives in livestock population changes, which highlights the importance of livestock production in the creation of agricultural producer economic account.

Table III.2. Production and economic potential of farms in voivodeships and its diversity in 2005 and 2016 (average)[a]

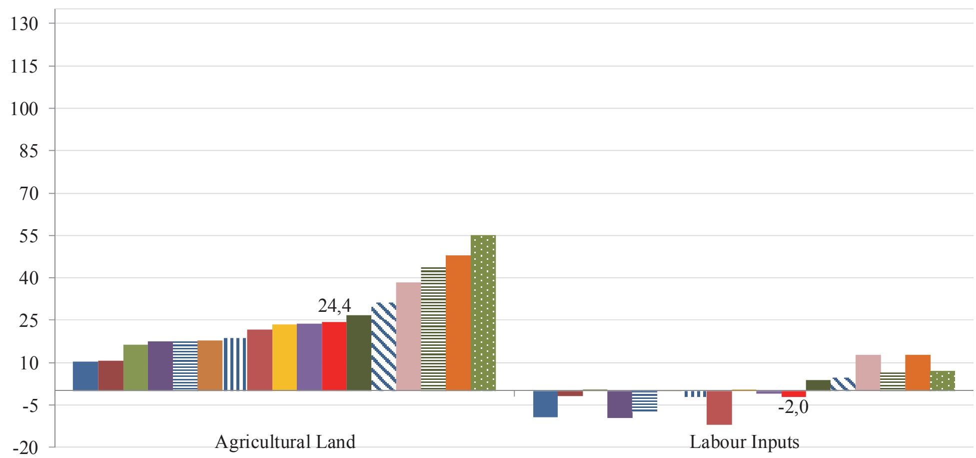
No.	Specification	AL (ha)	LI (AWU)	LD (LU)	SO (thousand EUR)	S_P
1	**2005 Poland**	**7.58**	**1.18**	**5.15**	**12.08**	**0.55**
2	Dolnośląskie	9.79	0.90	3.53	12.54	0.50
3	Kujawsko-pomorskie	12.50	1.35	9.18	23.61	0.84
4	Lubelskie	6.49	1.22	3.56	9.61	0.48
5	Lubuskie	11.75	0.91	5.66	14.73	0.59
6	Łódzkie	6.87	1.27	4.97	11.71	0.55
7	Małopolskie	3.08	1.16	2.10	5.27	0.35
8	Mazowieckie	7.54	1.23	5.97	13.18	0.58
9	Opolskie	10.13	1.08	5.58	16.07	0.61
10	Podkarpackie	3.41	1.07	1.72	4.89	0.33
11	Podlaskie	11.13	1.26	10.42	16.75	0.76
12	Pomorskie	12.26	1.14	7.40	17.59	0.71
13	Śląskie	4.08	0.87	2.75	5.98	0.33
14	Świętokrzyskie	4.78	1.31	3.06	8.39	0.45
15	Warmińsko-mazurskie	17.55	1.25	13.52	23.31	0.97
16	Wielkopolskie	11.11	1.35	9.69	21.55	0.81
17	Zachodniopomorskie	17.84	0.90	6.41	19.56	0.74
18	V_{SD}	46.31	13.88	53.18	41.86	30.31
19	V_{AD}	38.60	11.77	41.98	35.24	24.82
20	V_{QD}	28.33	8.16	32.69	28.64	21.60
1	**2016 Poland**	**9.43**	**1.16**	**8.31**	**15.61**	**0.54**
2	Dolnośląskie	13.55	1.01	4.48	16.89	0.52
3	Kujawsko-pomorskie	14.71	1.36	14.13	27.83	0.80
4	Lubelskie	7.63	1.13	4.74	11.02	0.43
5	Lubuskie	17.39	1.03	13.14	23.61	0.72
6	Łódzkie	7.57	1.15	8.23	14.02	0.50
7	Małopolskie	3.82	1.15	2.15	6.11	0.33
8	Mazowieckie	8.77	1.24	11.81	17.92	0.60
9	Opolskie	14.57	1.15	9.23	22.16	0.65
10	Podkarpackie	4.15	0.94	1.39	5.10	0.28
11	Podlaskie	13.21	1.23	18.17	21.11	0.75
12	Pomorskie	16.10	1.19	11.10	21.78	0.70
13	Śląskie	6.32	0.93	4.54	9.17	0.37
14	Świętokrzyskie	5.62	1.18	3.28	9.13	0.39
15	Warmińsko-mazurskie	21.68	1.26	22.13	30.99	0.97
16	Wielkopolskie	12.30	1.33	16.44	26.91	0.78
17	Zachodniopomorskie	22.62	0.94	10.04	25.67	0.74
18	V_{SD}	47.43	11.14	59.71	43.00	31.79
19	V_{AD}	40.66	8.88	49.11	37.06	27.49
20	V_{QD}	30.40	8.96	44.78	35.08	26.04

[a] symbols as in Table III.1; S_P – indicator of synthetic production potential of farms

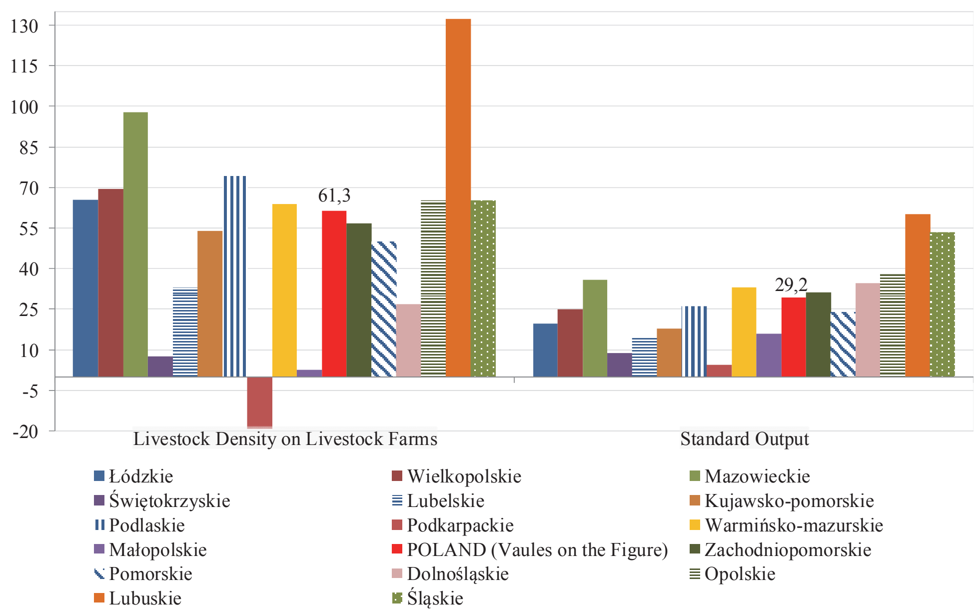
Source: own calculation based on data for 2005 and 2016 of CSO.

Figure III.3. The changes of the average farm's production and economic potential in the period of 2005-2016 (%)

3a. Agricultural land and labour inputs change



3b. Livestock density in livestock farms and standard output change



Source: own calculation based on data for 2005 and 2016 of CSO.

Development processes caused increasing differentiation, divergence process, of Polish farms in terms of their production potential (Table III.2). The process particularly applied to livestock production, followed by farms' size and generated volume of production (that was also confirmed by increasing variation indicator, in 2005 and 2016). In other words, the existing model for agriculture and agricultural holdings' development is strengthened in the regional division. The regions targeted at livestock production increased this production scale and improved farms' specialization, while others realized the process of livestock production withdrawal and enlargement of the crop production area. This indirectly indicates the progressive stratification of these two production directions at the farm and the region level.

Whereas farms in different regions became similar in the scope of unit labour inputs that indicated regional convergence process. Regardless of the development direction of production organization, farms in the regions aim at improvement of human factor exploitation. The employment problem in agriculture, associated with both the number of people interested in this work, the quality of work performed by employees, as well as remuneration obligation (which is less favourable in comparison to salaries in non-agricultural activities) are undoubtedly incentives for farmers to look for organizational and technological solutions aimed at the efficient use of labour input [Karwat-Woźniak 2015].

4. Agriculture economic efficiency

The Farm Structure Surrey data allowed for setting the indicator values of agriculture economic efficiency based on farms' evaluation. Farms' economic efficiency was assessed on the basis of land productivity and labour profitability. Land productivity was determined as the value of standard output per hectare of agricultural land (EUR thousand/ha). This indicator presents the level of land standard productivity. It is an important indicator of agricultural production volume in the context of food security. Whereas, labour profitability was the result of the value of standard gross margin per full-time employee (ESU/AWU). This indicator can be used as the measure of potential labour charges and the assessment of labour economic efficiency. As a result, this indicator informs about potential investment and consumption funds of households and farms.

Presented values indicated improvement in farms' economic efficiency in the analysed period that concerned land productivity and labour economic efficiency (Table III.3, Figure III.4). In the context of ensuring food security particularly important is increase in land productivity. The average land productivity (standard output per hectare of agricultural land) was 1.66 thousand EUR/ha (2016), that increased about 4% in the analysed period (1.59 thousand EUR/ha in 2005). This increase can be considered rather small, although it was in the desired direction. In this context, decrease in livestock production in the period played an important role that affected the total value of agricultural production.

The biggest positive changes were recorded in the potential labour charges. The standard gross margin per labour unit was used as a measure of the economic efficiency of labour and capacity of the farm to income generation. The data showed that the value of standard gross margin on the average farm was less than 5.74 ESU/AWU in 2016 and increased more than 17% in the analysed period (4.90 ESU/AWU in 2005). The significant progress of potential labour charges was not only the effect of standard gross margin improvement, but also (or even mostly) significant labour input decrease, as the effect of farm reorganization towards agricultural production simplification (including livestock production withdrawal) and higher specialization level.

Table III.3. Economic efficiency of agriculture in voivodeships and its diversity (2005 and 2016)[a]

No.	Specification	2005		2016	
		SO/AL (thousand EUR/ha)	SGM/LI (ESU/AWU)	SO/AL (thousand EUR/ha)	SGM/LI (ESU/AWU)
1	**Poland**	**1.59**	**4.90**	**1.66**	**5.74**
2	Dolnośląskie	1.28	6.74	1.25	7.63
3	Kujawsko-pomorskie	1.89	7.97	1.89	8.74
4	Lubelskie	1.48	3.92	1.44	4.63
5	Lubuskie	1.25	7.92	1.36	9.27
6	Łódzkie	1.70	4.49	1.85	5.29
7	Małopolskie	1.71	2.19	1.60	2.38
8	Mazowieckie	1.75	5.05	2.04	5.84
9	Opolskie	1.59	6.86	1.52	8.22
10	Podkarpackie	1.43	2.31	1.23	2.59
11	Podlaskie	1.50	6.08	1.60	6.95
12	Pomorskie	1.44	7.81	1.35	8.17
13	Śląskie	1.47	3.38	1.45	4.20
14	Świętokrzyskie	1.76	3.16	1.63	3.58
15	Warmińsko-mazurskie	1.33	8.97	1.43	10.19
16	Wielkopolskie	1.94	7.34	2.19	7.79
17	Zachodniopomorskie	1.10	11.16	1.13	12.50
18	V_{SD}	14.54	41.33	18.03	40.16
19	V_{AD}	12.16	35.48	14.47	33.89
20	V_{QD}	8.93	32.99	9.50	26.83

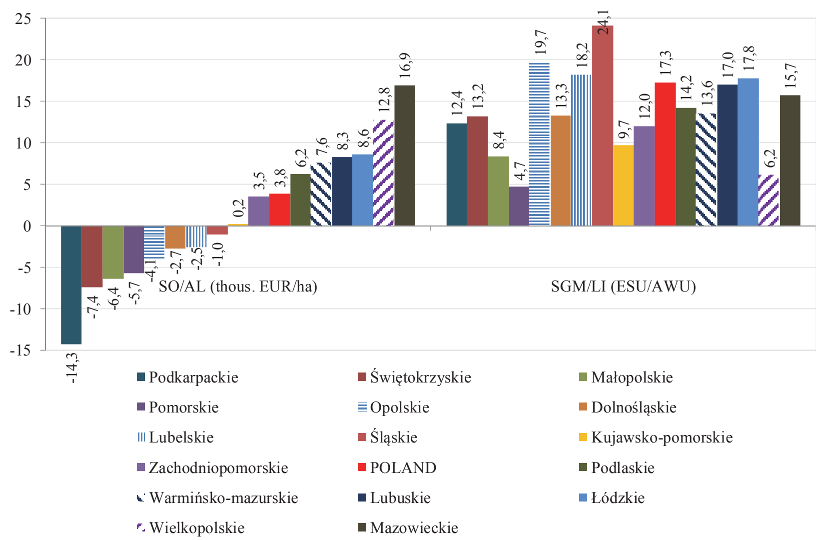
[a] symbols as in Table III.1; SGM – standard gross margin expressed in ESU.

Source: own calculation based on data for 2005 and 2016 of CSO.

Taking into consideration regional division, agriculture is very diversified in terms of the values of efficiency indicators. With regard to land productivity, a decline was observed in half of the voivodeships during the analysed period. The scope of changes was significant and ranged from -14% (in Podkarpackie) to +17% (in Mazowieckie). The largest declines in land productivity were concentrated on regions with intensive livestock production withdrawal, while defined progress took place in voivodeships aimed at the development of this production direction.

In the case of labour profitability, there was an improvement in each of the voivodeships during the period, although its scope was considerably varied (from 5% in Pomorskie to 25% in Śląskie). With regard to the latter, Śląskie region is the area in which very large reduction in agriculture employment is observed, which was reflected in labour efficiency indicators.

Figure III.4. The changes of agriculture economic efficiency in voivodeships in the period of 2005-2016 (%)



Source: own calculation based on data for 2005 and 2016 of CSO.

5. Changes in agricultural production direction and farming types

Due to the environmental reasons, agricultural production profile is particularly important. Agricultural production profile is reflected in farming types of agricultural holdings [Wrzaszcz 2017]. In accordance with the specification used in EUROSTAT and agricultural accounting system FADN, General Types of Farming classification was applied in the research, based on agricultural standard output value [Goraj et al. 2012; Bocian et al. 2017]. According to this classification, farming types reflect the profile of agricultural production, including the agricultural production orientation and activity, as well as the scope of specialization. The following types of farms were differentiated: I – specialized in field crops, II – specialized in horticultural crops, III – specialized in permanent crops, IV – specialized in rearing grazing livestock, V – specialized in rearing granivores, VI – mixed – various crops, VII – mixed – various animals, VIII – mixed – various crops and animals.

Livestock production has particular importance for the natural environment. On the one hand, livestock manure used in crop fertilization, enriches the resources of soil organic matter and exerts a positive impact on the environment. Keeping the desirable balance of soil organic matter and macronutrients is much more difficult on farms without livestock. On the other hand, potential threats to ecosystems are observed in the case of highly intensive livestock production due to ammonia emissions or the risk of groundwater pollution.

As indicated in numerous studies, farms with mixed crop and livestock production are characterized by the highest level of environmental sustainability [Wrzaszcz 2014; Zegar 2012]. In the case of mixed farms, connection between crop and livestock production is much stronger than in other types of agricultural holdings. Two elements play here an important role, namely: the adjustment of the structure of field crops for livestock forage requirements, as well as the use of natural fertilizers in crop fertilization. Those links reduce the dependence of agricultural holdings on external entities, both in terms of purchase of feed and chemical fertilizers. The use of natural fertilizers and relatively low input of industrial means of production result in the quality of agricultural products. Relatively lower stocking density on non-specialized farms in comparison with more intensive livestock production, limit the risk of local water and soil contamination [Kopiński 2017]. Empirical studies also confirmed the favourable results of fertilizer balance in the case of mixed farms [Kopiński 2006]. A diversified crop structure and the use of natural fertilizers are also factors determining the maintenance of soil production potential, which is one of the basic requirements of sustainable agriculture [Krasowicz 2005; Kuś et al. 2008].

During the examined period there have been significant changes in the field of carried out agricultural production (Table III.1). Many farms resigned from livestock production – the number of farms with livestock decreased by 43% (from 1,247.6 thousand farms in 2005 to 712.6 thousand farms in 2016). It was tantamount to the growing population of non-livestock farms, which in previous years conducted livestock production as secondary agricultural activity. Livestock production requires significant labour inputs, the large involvement of farmer in daily on-farm duties and investments connected with building equipment and animal welfare. The outflow of labour force from agriculture and farms' transformation related to agricultural production simplification, contributed to resignation from labour-intensive and demanding livestock production. This process had a negative environmental impact, due to a reduction in the amount of natural fertilizers of livestock origin and the progressive dependence of agricultural production on mineral and chemical fertilizers. The measurable effect of reducing the amount of natural fertilizers on non-livestock farms is a change in soil organic matter balance, which may be reduced partly by reorganizing agricultural production towards increasing the structure-forming crops or purchasing these fertilizers from producers involved in large-scale livestock production. Large-scale livestock production creates potential possibilities to natural fertilization turnover (usually, natural fertilizer production exceeds own specialized farm's demand).

Presented changes in agricultural production direction are reflected in farms' typology (Table III.4, Figure III.5). Taking into consideration *General Types of Farming*, both in 2005 and in 2016, farms specialized in crops (types I, II, III in total) dominated, and their share strongly increased in this period (from 45% to 64%). It should be added that this is the only farms' group, which so greatly increased in number.

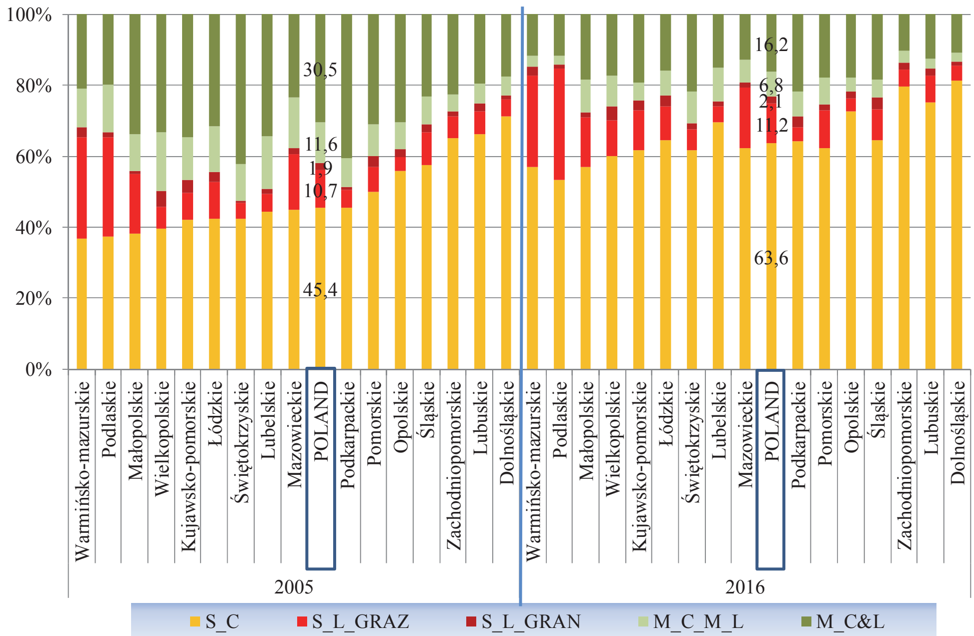
Mixed farms with various crops and livestock were in the second place taking into consideration farming type structure. The percentage of this group decreased by half in the research period. These changes can be considered as disadvantageous in terms of farms' environmental sustainability. Narrow specialization in crop production requires significant organizational activities to ensure the indicated level of environmental sustainability (e.g. the use of straw as organic fertilizer or the increasing share of cultivated crops that build soil structure and organic matter). Simultaneously, a significant decrease in the number was visible in the case of non-specialized agricultural holdings with mixed livestock. At the same time, the comparable share of farms specialized in livestock production, precisely in cattle and rearing granivores, remained in the analysed period.

Table III.4. Structure of farms' types in Poland in 2005 and 2016 (%)

<table>
<tr><th rowspan="4">Year</th><th colspan="8">Types of farming</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th><th>V</th><th>VI</th><th>VII</th><th>VIII</th></tr>
<tr><td colspan="5">specialized in:</td><td colspan="3">not specialized:</td></tr>
<tr><td colspan="3">crops</td><td colspan="2">livestock</td><td>crops</td><td>livestock</td><td>crop & livestock</td></tr>
<tr><td>2005</td><td>40.97</td><td>1.61</td><td>2.86</td><td>10.66</td><td>1.90</td><td>3.67</td><td>7.89</td><td>30.45</td></tr>
<tr><td>2016</td><td>57.81</td><td>1.63</td><td>4.20</td><td>11.21</td><td>2.13</td><td>3.30</td><td>3.53</td><td>16.18</td></tr>
<tr><td rowspan="3">difference in p.p.</td><td>16.84</td><td>0.03</td><td>1.34</td><td>0.55</td><td>0.23</td><td>-0.36</td><td>-4.36</td><td>-14.27</td></tr>
<tr><td colspan="5">19.00</td><td colspan="3" rowspan="2">-19.00</td></tr>
<tr><td colspan="3">18.21</td><td colspan="2">0.79</td></tr>
</table>

Source: own calculation based on data for 2005 and 2016 of CSO.

Figure III.5. Farming type structure in voivodeships in 2005 and 2016[a]



[a]S_C – farms specialized in crop production (I, II and III type); S_L_GRAZ – farms specialized in rearing grazing livestock (IV type); S_L_GRAN – farms specialized in rearing granivores (V type); M_C_M_L – non-specialized farms with mixed crop production and farms with mixed livestock production (VI, VII type); M_C&L – non-specialized farms with mixed crops and livestock production

Source: own calculation based on data for 2005 and 2016 of CSO.

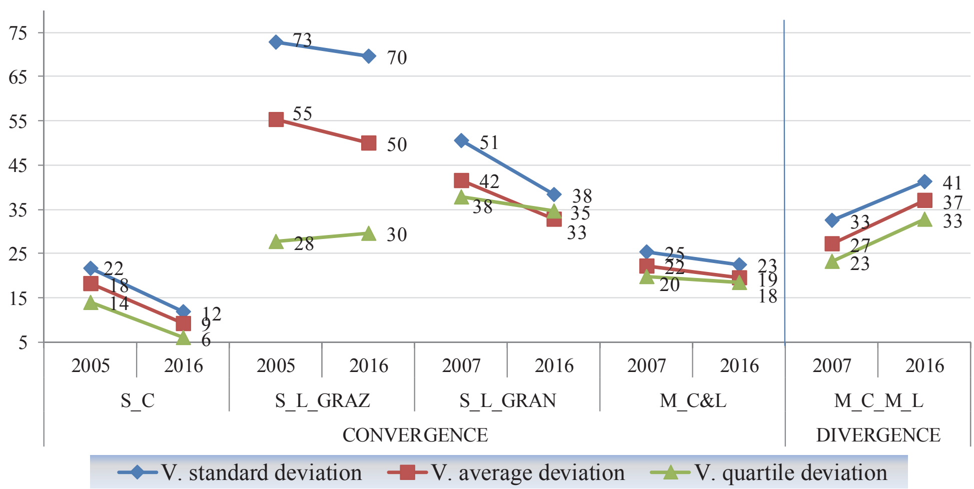
Presented numbers indicated, that in the last decade the process of farms' specialization was observed; the number of specialized agricultural holdings significantly increased (mainly specialized in field crops), at the expense of those with mixed production (especially mixed livestock and crop production). The significant part of non-specialized farms relinquished from livestock production during the period, solely or mainly in favour of field crops.

In the regional layout, agriculture significantly differs in terms of farming types. This is the result of previously submitted regional diversity of agriculture production potential. Generally, in each of the voivodeships, both in 2005 and 2016, dominated farms specialized in crop production. The percentage of those farms significantly increased during the analysed period, in each of the regions. Those results confirmed the universality of specialization process in the direction of crop production.

Slightly different situation is presented in specialized livestock production. The regions, such as Warmińsko-mazurskie and Podlaskie are areas that aim at specialization towards milk production, while the regions, such as Wielkopolskie, Kujawsko-pomorskie, Łódzkie and Śląskie are characterised by relatively more common specialization in rearing granivores.

Interesting changes in terms of the percentage of farms specialized in livestock production were observed in regional division. With regard to type IV – concerning mainly specialization towards milk production, there was an increase in the percentage of farms specialized in this production in Pomorskie, Kujawsko-Pomorskie, Wielkopolskie and Podlaskie, in the period of 2005-2016. In those areas, the importance of the considered livestock production profile increased. While agricultural holdings in Małopolskie or Warmińsko-mazurskie (the regions of milk production) started to withdraw from this specialization. It can be concluded that, on the one hand, there is an increase in the percentage of specialized farms of type IV in the regions with production potential for development of this production profile. While, on the other hand, the part of farms located on those areas, started to withdrew from this production activity and switched to the specialized crop production.

Figure III.6. Regional convergence and divergence of farming types based on variation indicators (%)[a]



[a] symbols as in Figure III.5.

Source: own calculation based on data for 2005 and 2016 of CSO.

With respect to type V, concerning farms specialized in rearing granivores – pigs and poultry, only Podkarpackie and Śląskie were the regions with increasing percentage of such farming type. In other voivodeships stagnation or withdrawal from this agricultural activity was observed. It may be the symptom of deterioration on this agricultural market. At the same time, regions where the percentage of those farms increased, do not belong to voivodeships leading in this production. It is possible that the high competition on the market in the voivodeships already developed in this field (production), does not encourage others – smaller producers, to take the initiative in development of this production direction.

With regard to mixed farms (non-specialized), in each voivodeship the percentage of those farms fell, including type VIII and in total: VI and VII. Drops mostly concerned farms with mixed and combined livestock and crop production (VIII), indicating a lack of farmers' interest in diversification of production at the farm level. This is a negative phenomenon in the context of sustainable development.

Figure III.6 shows the results of regional disparities of farms' types. In general, voivodeships significantly and to a large extent differed in terms of farming types. Significant differences concerned farms' specialization in grazing livestock (IV). In the case of most types, regional diversity decreased due to the dissemination of specialization in crop production, as well as livestock production withdrawal. In this regard, the convergence process took place. While, divergence process concerned mixed (combined) crop and livestock production (type VIII) and regional diversity depended in this scope. Dolnośląskie, Lubuskie and Śląskie are regions, where definitely less mixed farms withdrew and simultaneously less specialized farms in crop or livestock production grew.

6. Farms' environmental sustainability

The results for the environmental sustainability of farms are presented in Table III.5. Based on the percentage of farms that met the threshold values for each of the environmental sustainability indicators, it can be concluded that the analysed criteria were varied in terms of difficulty level in their fulfilment. Most farms met the criterion of stocking density (in 2007 and 2016, 99% and 98% of farms had stocking density up to 2 LU/ha), then the balance of soil organic matter (a positive result characterized 55% and 72% of farms in the analysed years), and winter vegetation cover (in this case, 63% and 61% of farms, in 2007 and 2016, had a winter vegetation cover that took up at least 1/3 of the sown surface). As the research results indicated, appropriate crop diversification was very difficult in application, which was evidenced by the relatively low percentage of farms with the desired crop structure (at least 3 different crop groups were cultivated by every fifth analysed farm, while in the case of 28% in 2007 and 30% in 2016 of farms, cereals covered below 2/3 of cultivated arable land).

The evaluation of fertilizer balance, covering the main macronutrients, is a more complex issue. The balance of individual components may be understated, optimal or overstated in comparison to the recommended level. It is dictated by both the local circumstances, including macronutrients contents in soil, then quantity of supplied ingredients to soil in the form of various fertilizers (natural, organic and mineral), as well as the amount of components consumed by cultivated crops.

Table III.5. Farms' sustainability in Poland and voivodeships in 2007 and 2016 (% of farms fulfilling environmental sustainability criteria and synthetic indicator value)[a]

No.	Specification	Sustainability criteria concerning:								
		crops			live-stock	balances				S_S
		W	Ce	D	L_D	OM	N	P	K	
1	**2007 Poland**	63	28	34	99	55	8.5	9.7	3.7	0.78
2	Dolnośląskie	70	26	20	99	60	9.1	9.7	3.6	0.79
3	Kujawsko-pomorskie	72	31	40	98	77	10.4	8.5	4.0	0.92
4	Lubelskie	59	21	38	99	47	11.1	10.5	4.5	0.82
5	Lubuskie	62	25	17	99	40	8.6	10.8	2.7	0.69
6	Łódzkie	71	20	31	99	66	10.3	9.7	4.8	0.87
7	Małopolskie	62	44	38	99	49	6.9	7.6	2.9	0.73
8	Mazowieckie	63	25	35	98	51	8.5	10.0	3.5	0.76
9	Opolskie	66	21	24	99	80	6.6	12.0	5.3	0.84
10	Podkarpackie	62	40	44	100	34	6.6	8.4	3.1	0.69
11	Podlaskie	51	23	36	98	56	6.1	9.7	2.9	0.68
12	Pomorskie	63	27	33	98	69	9.6	11.6	4.2	0.87
13	Śląskie	54	28	21	99	59	5.9	11.3	2.5	0.69
14	Świętokrzyskie	61	30	44	99	46	10.2	10.2	4.0	0.82
15	Warmińsko-mazurskie	58	33	27	98	69	6.9	9.1	3.2	0.76
16	Wielkopolskie	75	17	26	96	82	8.0	9.8	4.3	0.84
17	Zachodniopomorskie	61	29	26	99	52	9.5	10.1	4.5	0.80
1	**2016 Poland**	**61**	**30**	**20**	**98**	**72**	**5.5**	**7.1**	**2.5**	**0.74**
2	Dolnośląskie	77	27	14	99	85	8.2	6.6	2.8	0.87
3	Kujawsko-pomorskie	60	36	31	97	78	7.6	9.0	3.0	0.90
4	Lubelskie	60	27	21	99	78	6.4	8.5	2.7	0.81
5	Lubuskie	75	25	15	99	84	5.7	7.9	2.0	0.78
6	Łódzkie	63	23	17	97	75	8.3	7.9	3.0	0.84
7	Małopolskie	55	36	20	98	55	3.0	3.4	1.4	0.56
8	Mazowieckie	58	28	17	97	71	4.6	6.8	2.1	0.68
9	Opolskie	79	22	17	99	92	7.3	9.6	3.6	0.92
10	Podkarpackie	60	33	19	99	49	3.1	6.1	2.0	0.59
11	Podlaskie	45	38	21	96	61	3.7	5.2	2.0	0.62
12	Pomorskie	59	31	25	98	79	7.6	7.6	2.5	0.85
13	Śląskie	64	26	13	98	84	3.7	7.4	2.0	0.69
14	Świętokrzyskie	61	30	30	99	55	7.2	7.0	2.5	0.77
15	Warmińsko-mazurskie	58	44	23	97	76	4.1	4.3	2.5	0.72
16	Wielkopolskie	69	25	18	95	88	5.4	10.6	3.9	0.87
17	Zachodniopomorskie	68	41	19	99	83	6.9	8.8	1.4	0.85

[a]sustainability criteria: W – in winter, Ce – cereals, D – diversification, L_D – livestock density per ha, OM – organic matter, N – nitrogen, P – phosphorus, K – potassium, S_S – environmental sustainability synthetic indicator

Source: own calculation based on 2007 and 2016 data of CSO.

The most difficult issue is to ensure optimum (recommended) balance, not to create excessive component surplus (which may be a hazard to the natural environment), as well as, the result may not be very low (it can lead to macronutrients depletion from soil and requires restoration during the next years) [Kopiński 2017]. As research indicated, less than 9% of farms in 2007 and 6% of farms in 2016 had the desired nitrogen balance, and in the case of phosphorus it was 10% and 7% of farms appropriately in the analysed years. While the most alarming situation applied to potassium, as only 4% in 2007 and 3% in 2016 of farms balanced the component.

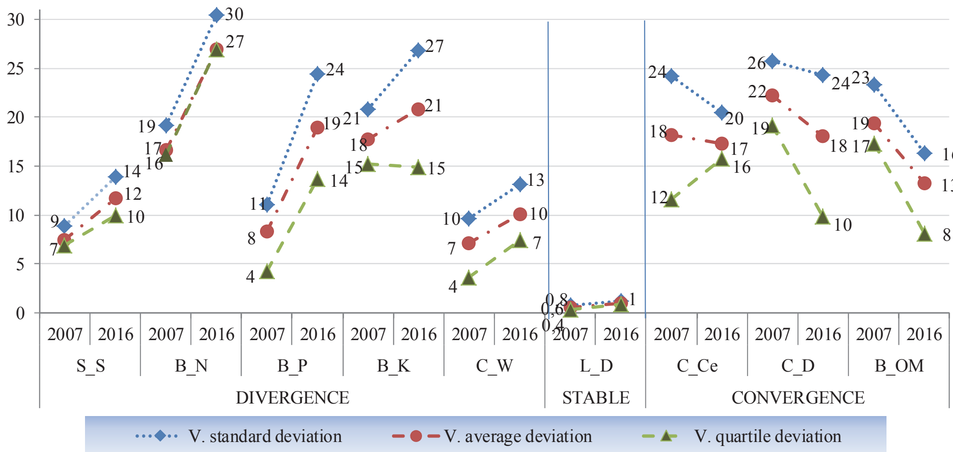
Summing up, between 2007-2016 there were changes in farms' sustainability. In the case of cereal indicator and soil production potential regenerating, progress was observed at the state level, while deterioration mainly concerned macroelements balancing. Positive changes were the effect of increasing surface of soil improving crops, especially legumes and papilionaceous. In the case of negative changes in agricultural production, the problem can be seen in terms of reduced natural fertilization [Wrzaszcz 2018]. Synthetic sustainability indicator also slightly decreased during the considered period ($S\_S_{2007} = 0.78$; $S\_S_{2016} = 0.74$).

In 2007 and 2016, in the regional division, farms significantly differed from each other in terms of environmental sustainability (considering most of the analysed indicators). Only stocking density criterion did not diversify farms between voivodeships. While the largest regional diversity concerned macronutrients balancing, as well as crop diversification, that was provided by the high level of variation indicators (Figure III.7). Also synthetic indicator of farms' sustainability significantly differentiated farms between regions (variation indicator was around the significance limit; $V_{SD\_2005} = 9\%$ and it increased in 2016 to the level of $V_{SD\_2016} = 14\%$ that confirmed diversity increase).

Comparing voivodeships' ranking in terms of synthetic farms' environmental sustainability in 2007 and 2016 (Table III.6), it can be concluded that in the group of voivodeships with the highest results were those with relatively high or average production potential. The best outcome characterized Opolskie and Kujawsko-pomorskie voivodeship, while the worst value concerned Podkarpackie and Małopolskie region (2016). During the period, the majority of voivodeships undermined its position in this classification.

Having regard to synthetic environmental sustainability change in regional aspect, deterioration in the farms' sustainability level was observed in most voivodeships (Central and Eastern Poland). The improvement was found in the Western regions (Map III.1). The Western voivodeships are also an area with a high production potential that can indicate wider farms' organizational possibilities, especially in crop production.

Figure III.7. Regional convergence and divergence of agriculture sustainability based on variation indicators (%)[a]



[a] symbols as in Table III.5.

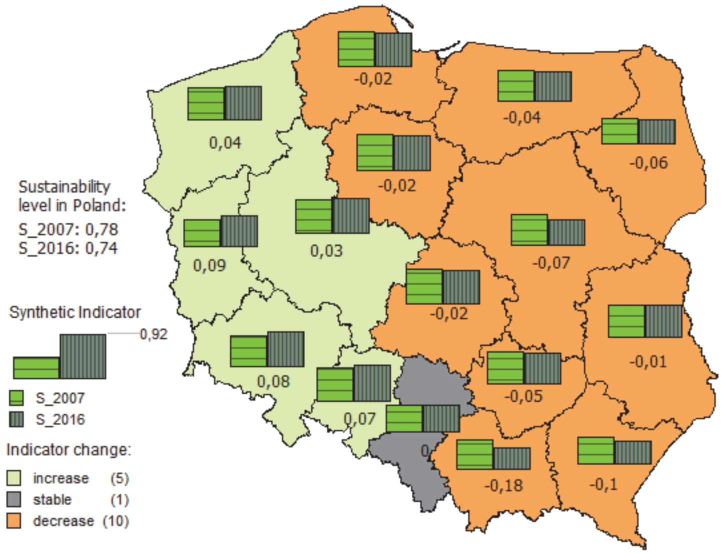
Source: own calculation based on data for 2007 and 2016 of CSO.

Table III.6. Quartile groups and voivodeships' positioning according to environmental sustainability level in 2007 and 2016

Quartile	2007	2016	2016/2007
I the lowest results	16. Podlaskie 15. Śląskie 14. Lubuskie 13. Podkarpackie	16. Małopolskie 15. Podkarpackie 14. Podlaskie 13. Mazowieckie	↓ ↓ ↑ ↓
II low results	12. Małopolskie 11. Mazowieckie 10. Warmińsko-mazurskie 9. Dolnośląskie	12. Śląskie 11. Warmińsko-mazurskie 10. Świętokrzyskie 9. Lubuskie	↑ ↓ ↓ ↑
III high results	8. Zachodniopomorskie 7. Świętokrzyskie 6. Lubelskie 5. Wielkopolskie	8. Lubelskie 7. Łódzkie 6. Zachodniopomorskie 5. Pomorskie	↓ ↓ ↑ ↓
IV the highest results	4. Opolskie 3. Łódzkie 2. Pomorskie 1. Kujawsko-pomorskie	4. Wielkopolskie 3. Dolnośląskie 2. Kujawsko-pomorskie 1. Opolskie	↑ ↑ ↓ ↑
↑ ↓	**Improvement/Deterioration** in positioning; 2016/2007		

Source: own calculation based on data for 2007 and 2016 of CSO.

Map III.1. Farms' environmental sustainability in Poland in 2007 and 2016 (synthetic indicator value and its changes)[a]



[a] values on the Map: change in synthetic indicator value of farms' environmental sustainability (S).

Source: own calculation based on data for 2007, 2016 data of CSO.

Based on the value change of variability indicator of individual sustainability criteria in the period of 2007-2016, convergence and divergence phenomenon was assessed (Figure III.7). Taking into consideration synthetic indicator of farms' environmental sustainability, the diversity of voivodeship deepened, which was mainly the effect of increasing regional differences in macronutrients balancing in soil and assurance of adequate winter crop cover. Whereas the part of the regions become similar to each other in the scope of crop production organization and soil organic matter balancing, which means convergence process. Comparing those processes, divergence process was more intensified (as was evidenced by larger differences in variation coefficients values for 2007 and 2016).

***

The paper presents the proposal for measuring regional convergence process in agriculture production potential, as well as environmental sustainability of farms in Poland using the FSS data. The presented approach to research can be useful in the European Union region analysis in the scope of sustainability diversification and agriculture development direction. Based on the research, the main conclusions are as follows:

- Between 2005 and 2016 there were significant changes in individual agriculture, which concerned land concentration and agricultural production simplification. Further intensification of those processes can bring environmental costs of agricultural activity.
- Farms withdrawal from livestock production should be considered as important environmental and economic problem. Taking into consideration sustainable development determinant, mixed crop and livestock production is optimal farm's organization, however, production diversification in agricultural practice is getting less frequent as well.
- Agriculture at the regional level is significantly different in terms of production potential and this phenomenon has deepened, reflecting regional divergence. Regional divergence to the largest extent applies to livestock production.
- Market conditions and legal standards encourage to farms' organization simplification, specialization improvement and agricultural production concentration. These conditions are reflected in economic factors (prices of means of production and agricultural products, as well as necessary investments), which determine agricultural producer decisions.
- Farms' economic efficiency partly enhanced in the period of 2005-2016, that was indicated by the increase of land productivity and labour profitability – the important determinants of food security and labour charges.
- Due to the high and increasing share of farms specialized in field crops, their organization and applied agricultural practices will mainly contribute to the environmental sustainability of agricultural sector.
- Farms' environmental sustainability includes various issues related to crop and livestock production. Studies have indicated that the considered sustainability criteria differ in terms of difficulty level of their fulfilment.
- Agricultural holdings differed significantly between regions in terms of environmental sustainability. The diversity particularly concerned proper macroelement balancing in soil. In this respect, regional divergence is the most intensive.
- Heterogeneous changes in farm environmental sustainability were observed, also at the regional level. Taking into consideration the synthetic indicator of environmental sustainability, some symptoms of regress were observed, which took place in the Central and Eastern Poland – the area with relatively lower production potential of agriculture.
- Farms' environmental sustainability partly enhanced in the scope of soil organic matter balance and crop structure improvement.

- In the context of farms' environmental sustainability, there is still the problem with insufficient crop diversification and progressive livestock production withdrawal that was reflected in macroelement balance.
- Regional diversity in the field of environmental sustainability deepens for most of its considered determinants, which confirmed divergence process. Diverse regional conditions of agricultural production and its specificity, and then different market influence on the farms' production organization in the specific voivodeship, determine the progressive process of regional divergence.
- The group of voivodeships characterised by the highest environmental sustainability in 2016 were not a homogenous group in the scope of agriculture production potential. On the one hand, in the group there were voivodeships where livestock production was developed and effectiveness improvement was observed in the period of 2005-2016 (e.g. Wielkopolskie). On the other hand, voivodeships such as Opolskie were included in this group, which were characterised by livestock production withdrawal and structural changes in area towards potential production increase. Those results are the confirmation of supplementation of environmental and economic purposes of agricultural activity, achieved by different organizational solutions.
- Voivodeships with the lowest result of environmental sustainability in 2016 showed high differentiation of agricultural potential and production organization. On the one hand, voivodships with fragmented agrarian structure and low economic outputs were classified into this group (e.g. Małopolskie). On the other hand, Podlaskie voivodeship was in this group characterised by both increase in area potential and livestock production (per average farm). The reasons for low environmental sustainability were: in the first case of voivodeships, small production potential constraining organizational capacity of crop production (on average); while in the latter one, the significant advantage of farms with intensive livestock production.
- Apart from the constituent elements of farms' production potential, possibilities of agriculture environmental sustainability are determined by production potential. Higher production potential of farms results in more favourable economic performance, but also enables realization of the environmental objective. This relationship between production potential and environmental sustainability is not linear in absolute terms. The environmental problems concerns usually the smallest and the biggest farms in terms of their production potential.

- Equalization of regional disparities requires the development of actions (programs) at the local level, taking into account the production capacity of the region, resulting from agriculture production potential of a specific area.
- The condition of the presented farms is definitely not sufficient, thus additional governmental incentives are desirable to move forward environmental sustainability, especially focusing on narrowing the gap in sustainability between regions.
- The accession of Poland to the European Union has helped to partly improve farms' sustainability as a result of rural development programmes implementation and conditional subsidising. This farmers' support aimed at improving the broadly understood efficiency of agricultural activity, as well as non-agricultural activities development in rural areas.
- The need for further research was emphasised to broaden recognition of farms' sustainability and the causes of this phenomenon, both of external conditions (national), and arising from the peculiarities of individual regions (internal conditions).

CHAPTER IV

SUSTAINABILITY OF FAMILY FARMS BY PRODUCTION AND ECONOMIC TYPE IN 2005 AND 2016

The diversification of farms is an immanent feature of agriculture all over the world. It is determined using many criteria, starting from the historically known criteria of ownership and area through the criteria on the purpose of produced goods (production orientation), types of labour inputs, size and relations of production factors to the latest criteria regarding the economic size and relation with the natural environment.

The dominant form of agriculture in the world are family farms. These farms form an enormous mosaic, taking into account the area of agricultural land, production volume, production purpose or relations between the farm and the household (family)[22]. There is no single, generally adopted definition of the family farm, which poses significant difficulties for comparative analysis. Dominant is an opinion that the family farm is managed by the family and that the family labour input prevails. An important feature differentiating family farms is also the share of farm income in household income. There are also other differentiating features such as the area of farmland, animal herds or the value of the agricultural production, either produced or implemented. This differentiation in the criteria of identifying family farms (also farms in general) makes it difficult to determine the number of family farms and the area of farmland they use[23].

Polish statistics identifies farms with legal personality and individual farms (farms managed by natural persons)[24]. The latter are equated with family

[22] For the purposes of simplicity, I will treat these terms alternately, without going into detail on differences between "household" and "family".

[23] It is estimated that on the global scale, family farms account for 88% of all farms, use about 75% of agricultural land and deliver about 80% of the agricultural production [FAO 2014]. Also other figures are provided, depending on the definition of the farm, scope and time of an agricultural census and the definition of agricultural land and agricultural production – see e.g. [Béliérs et al. 2015; Graeub et al. 2016].

[24] In the agricultural structure survey of 2005, the individual farm was *a farm with an area of agricultural land from 0.1 ha, being owned or used by an individual or a group of persons and a farm of a person having no agricultural land or having agricultural land of less than 0.1 ha who has at least: one head of cattle or (and) 5 heads of pigs or 1 sow or (and) 3 heads of sheep or goats or (and) 1 horse or (and) 30 heads of poultry or (and) 5 females of fur animals (including rabbits) or (and) 1 bee family* [GUS 2006a, p. 19]. These thresholds were increased in the survey of 2016 [GUS 2017a, p. 18]. In addition, in the survey of 2005 the sampling frame were farms pursuing and not pursuing agricultural activities (2.9 million farms) while in the survey of 2016 only farms with agricultural activities and an area of 1 ha and more,

farms. For the purposes of the paper, all individual farms were treated as family farms[25]. Due to changes in the definition of individual farms – for the comparability of generalised results in the analysed years (2005 and 2016) – we limited ourselves to individual farms pursuing agricultural activities and keeping agricultural land (AL) in Good Agricultural and Environmental Conditions (GAEC). The analysed population covers farms with an area of 1 and more ha of utilised agricultural area (UAA)[26]. In 2005, per analysed group of farms there were 87.6% of AL out of whole agriculture (in 2016 – 91.4%), labour inputs in AWU 88.8% (91.5%), livestock population (LU) 90.0% (88.0%), standard output 88.4% (87.5%) and standard gross margin 88.4% (90.0%)[27].

Family farms – with few exceptions[28] – correspond to households of users of such farms. Public statistics usually identifies socio-economic types of households of farm users according to the criterion of dominant income and allows to describe both households and corresponding farms. This paper used two criteria to differentiate the population of family farms, namely the source of livelihood for the family (household) with the farm user and the production purpose. For the first criterion, the Ockham'a razor is the type (origin) of income being a dominant[29] source of livelihood for the household (own agricultural activities, other sources of income), while for the other – the purpose of the dominant agricultural production (for the market or for own purposes of the household). In this way, four production and economic types (groups) of farms have been identified, which were conventionally named as follows: professional farms, i.e. those that provide income being a dominant source of livelihood for the household (family) using this farm and also implement the dominant value of agricul-

---

meeting the increased threshold requirements (1,544 thousand farms). In 2005, the sample was about 200 thousand farms and in 2016 about 180 thousand farms.

[25] According to the data of the CSO agricultural structure surveys of 2005 and 2016, the percentage of individual farms with the advantage of paid labour force [which in most definitions are considered non-family (Capitalist) farms] decreased from 1.84% to 1.63%, with an increase in the share of paid labour force in total labour inputs from 3.97% to 7.57% (labour inputs expressed in AWU).

[26] I would like to mention that in the CSO publication, the analysed population covers farms of more than 1 ha of AL. Covering farms of 1 ha with the analysis increased the analysed population – e.g. in 2016 by 14.2 thousand farms.

[27] The analysed population of farms for 2005 excludes 649 thousand farms using 304.4 thousand ha of AL, including 271.6 thousand ha kept in GAEC and for 2016 – 8.5 thousand farms of up to 1 ha of AL using 6.6 thousand ha of AL, including 1.5 thousand ha kept in GAEC. In 2005, 2.1 thousand farms with the area of AL of 1 ha and more were excluded while in 2016 – 2 thousand farms which did not keep agricultural land in GAEC.

[28] There were situations where one farm is used by persons forming separate households (in statistical terms of household).

[29] Namely exceeding 50%.

tural production on the market (marked with the symbol A); auxiliary farms, i.e. those that implement a dominant part of production on the market, while a dominant source of livelihood is income other than farm income (B); hobby farms, i.e. those whose dominant income comes from other sources than the farm and that produce mainly for own purposes (C); traditional farms (rustic, problematic), i.e. those that live mainly on income from own farm and are also dominated by self-supply (D).

The applied criteria of identifying types of family farms are justified substantively, as they refer to two basic production and economic objectives of farms (and even of agriculture), i.e. production and income. The farm's orientation towards the market production or towards self-supply is of essential importance to organisation of the farm. In the first case, the farm is subordinate to the market logic with regard to the production structure, technology (production methods) and economic account. In this case, the farm is oriented towards the supply of agricultural products, which determines its contribution to providing food security under the cross-sector food system[30]. On the other hand, farms oriented towards self-supply are not guided by the market logic, while even if they use economic account, it differs significantly from classical account oriented towards obtaining the maximum economic benefits. In the second case – of farm income, if it is a dominant source of livelihood for the family, it significantly determines the attitude towards the farm. If this income is satisfactory, the farm can be treated as independent, regardless of the area of agricultural land. However, if income is not satisfactory, in the case of type A farms, there is a problem with the future of the farm as it has to choose one of the three options: 1) increasing the economic power of the farm by increasing the area and/or the production scale, 2) taking up additional non-agricultural employment (paid or self-employment – also based on the farm's assets) or, in general, becoming type B and 3) liquidation of the farm (sale, lease). Such options are also faced by type D farms, but of decisive importance in this case is the human factor while option 1) is rare. In type B farms, as non-agricultural income increases, the most probable option will be to become type C or to liquidate the farm; only a small fraction of farms of this type see their future in developing agricultural activities on the farm.

The currently conducted studies confirm the assumptions that farms identified according to these criteria are significantly different in terms of the value of their characteristic features. The study attempted to determine if this applies also to the development path (changes over time) with a particular consideration given to farm sustainability indices.

[30] In this case this not much neat term specifies the food system excluding self-supply.

The objective of the paper is to describe and present changes in the identified types of farms with a particular focus on the selected indices of environmental, economic and social sustainability. Naturally, the selection of these indices has been dictated by the data available in the study of agricultural structures.

The following layout of the presentation has been adopted: synthetic characteristics of the production potential of the selected family farm population (1), advancement in the industrialisation process of farms: commercialisation, intensification, concentration and specialisation (2), environmental (3), economic (4) and social (5) sustainability and the summary.

1. Production potential of farms by production and economic types

The production potential is of key importance to both the present state and the future (prospects) of the selected types of farms. In assessing this potential, relevant are both values referring to a total of farms of a given type and to the average farm of a given type. In the first case, these values point to the agricultural structure in terms of types of farms, while in the other – to the direction of changes in transformation of farms. The description of the production potential includes the most basic features, namely: the number of farms, total area and agricultural land in GAEC, area of arable land, labour inputs, livestock population, standard output value and standard gross margin value[31]. Values of the presented features were summarised for 2005 and 2016. The major arrangements apply to the importance of farms of given types in the whole population of analysed farms, values for the average farm and changes over time.

The accession of Poland to the European Union in 2004 lifted or at least alleviated barriers to transformation of agriculture according to the farmer trajectory followed by the majority of the developed countries. The point here is, in particular, the barrier to income and employment[32]. After the accession, the number of farms was decreasing, the labour inputs were decreasing even faster, the area used by agriculture was decreasing while the land productivity (standard output) was increasing. There are some derogations from general principles. The area of agricultural land in GAEC even slightly increased, while the livestock population decreased. In relation to agricultural land, this was determined by the direct payment instrument (prerequisite to receive direct payments) which

[31] I would like to stress that what escapes us here is the very important value referring to capital (fixed assets) which was not a subject of the agricultural structure survey.

[32] The barrier to income consists in the shortage of resources for maintenance of the farm family (consumption) and – or even first of all – for production investments on the farm. On the other hand, the barrier to employment (labour) consists in the insufficient demand for labour force in non-agricultural sectors, which would attract at least surpluses of labour resources (labour force) from households with the farm user. See more [Zegar 2018].

brought set-aside land (and fallow land)[33] back to the agricultural use, while the decrease in the livestock population is related mostly to the economic situation (is not a principle of agricultural transformation). There was also a decrease in the volume of standard gross margin, which results from the too low increase in the productivity of production factors and the progressive substitution of living labour for objectified labour (agricultural technology). Such changes are pointed out by the data provided in Table IV.1. These changes applies to individual farms with an area of at least 1 ha of AL, pursuing agricultural activities and keeping agricultural land in GAEC (family farms) with the identification of production and economic types.

Table IV.1. Basic features of the production potential of family farms in total and by production and economic types in 2005 and 2016

Specification	Total	Production and economic types			
		A	B	C	D
	2005				
Number of farms (thousand)	1,723.9	526.2	670.6	432.6	94.5
Total area (thousand ha)	15,131.2	8,731.5	3,909.9	1,596.3	893.5
Agricultural land in GAEC (thousand ha)	13,060.6	7,879.9	3,240.1	1,168.9	771.7
Arable land (thousand ha)	9,901.6	6,250.3	2,363.6	725.5	562.2
Labour input (thousand AWU)	2,035.2	955.8	574.0	360.9	144.6
Livestock population (thousand LU)	6,430.3	4,585.0	945.9	428.4	471.1
Standard output (SO) (million EUR)	20,824.1	13,891.4	4,090.8	1,540.3	1,301.6
Standard gross margin (SGM) (million EUR)	9,970.9	6,540.6	2,045.4	770.0	614.9
	2016				
Number of farms (thousand)	1,398.1	428.7	506.1	428.8	34.5
Total area (thousand ha)	14,869.9	9,104.9	3,738.5	1,800.7	225.8
Agricultural land in GAEC (thousand ha)	13,181.4	8,371.6	3,207.4	1,416.6	185.8
Arable land (thousand ha)	9,765.7	6,525.9	2,422.5	691.4	126.0
Labour input (thousand AWU)	1,617.0	817.2	427.4	321.9	50.6
Livestock population (thousand LU)	5,923.5	5,184.1	569.9	132.8	36.8
Standard output (SO) (million EUR)	21,824.3	16,604.6	3,881.7	1,142.1	195.9
Standard gross margin (SGM) (million EUR)	9,282.4	6,743.9	1,857.4	583.1	98.0

Source: own calculations based on the results of studies on the agricultural structure in 2005 and 2016, calculated by Statistical Office in Olsztyn for the purposes of the Multi-Annual Programme 2015-2019.

[33] In 2005, the agricultural land area not kept in GAEC amounted to 363 thousand ha and in 2016 – 107 thousand ha, i.e. more than three times less (this applies to the analysed population of family farms).

The above changes, pointing to the progressive deagrarisation of the social farm, differed significantly, when taking into account the identified types of family farms. In 2005-2016, as dominant we could consider two changes pointing to the multiannual trend of industrial transformation of family farming. The first change applies to strengthening of farms heading for farms specified as professional farms (type A farms), i.e. market-oriented and subject to agriculture industrialisation processes (commercialisation, input intensification, concentration and specialisation). This is expressed mainly in the livestock population (increase in the share in the whole analysed population of farms by 16.2% – to 87.5%) and in the standard output (increase by 9.4% – to 76.1% – see Table IV.2[34]).

Table IV.2. Structure of the production potential of farms of identified production and economic types in 2005 and 2016 (in total = 100)

Specification	Production and economic types							
	A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016
Number of farms	30.5	30.7	38.9	36.2	25.1	30.7	5.5	2.5
Total area	57.7	61.2	25.8	25.1	10.6	12.1	5.9	1.5
Agricultural land in GAEC	60.3	63.5	24.8	24.3	9.0	10.7	5.9	1.4
Arable land	63.1	66.8	23.9	24.8	7.3	7.1	5.7	1.3
Labour input	47.0	50.5	28.2	26.4	17.7	19.9	7.1	3.1
Livestock population	71.3	87.5	14.7	9.6	6.7	2.2	7.3	0.6
Standard output	66.7	76.1	19.6	17.8	7.4	5.2	6.3	0.9
Standard gross margin	65.6	72.6	20.5	20.0	7.7	6.3	6.2	1.1

Source: as in Table IV.1.

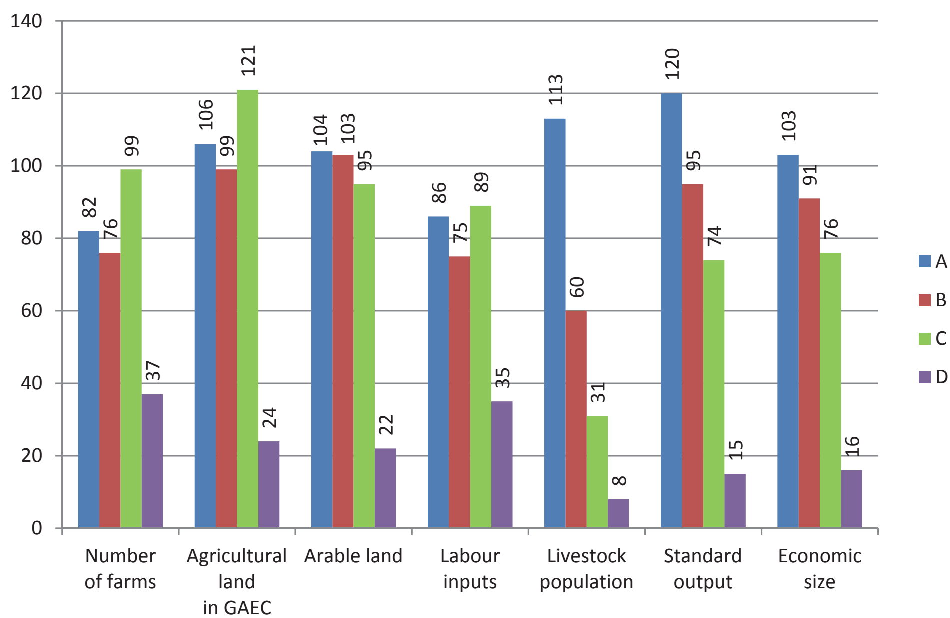
This points to the growing importance of this type of farms in the agricultural production. The second change applies to traditional rustic farms (type D) which – in accordance with predictions of the classical authors of the agrarian question – are disappearing, going off the scene. They account for a negligible percentage of the production potential while giving rise to a certain social problem. With reference to two-profession (or rather two- or multi-income)[35] farms, changes point to their diminishing position in the field of production, mostly livestock. On the other hand, while auxiliary farms (type B) also show a reduction in the share in agricultural land and labour input, hobby farms (type C) show an increase in this regard. This is mainly a result of a response to the CAP instruments

[34] In tables regarding structures, there may be deviations of up to 0.1%, resulting from rounding.
[35] Two-profession farms mean that family members conduct at least two different economic activities, while two-income farms mean that income is derived from at least two sources, including also unearned income (social benefits and allowances, but also income from capital).

after the accession of Poland to the European Union. Type B farms made greater use of the possibility to draw benefits from the development of non-agricultural activities, while type C farms saw benefits in farm resources – mostly entitlements to area payments (directly or through the land lease – including, in particular, permanent grasslands which were previously set aside).

The changes, presented on Figure IV.1, are confirmed by the values of features of the average farm of the identified type (Table IV.3). Type A farms increase their advantage over other types with regard to the production and economic potential. The area of AL on the average farm in the whole population grew by 22%, while in type A farms by 30% (type B by 28%, type C by 13%, while in type D it declined by 36%). The standard output volume increased in the analysed population (for all farms) by 29%, including in type A farms by 47% and in type B farms by 26% while a decrease took place in type C farms – by 25% and in type D farms by as much as 41%. Similar changes took place with respect to the livestock population: increase in type A and B farms, decrease in type C and D farms.

Figure IV.1. Changes in basic categories of production and economic types of family farms in 2005 and 2016 (%)



Source: own calculations based on the results of studies on the agricultural structure in 2005 and 2016, calculated by Statistical Office in Olsztyn for the purposes of the Multi-Annual Programme 2015-2019.

Table IV.3. Production and economic potential of farms of identified types in 2005 and 2016 (on average per farm)

Specification	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Agricultural land (ha)	7.8	9.5	15.1	19.6	5.0	6.4	3.0	3.4	8.4	5.4
Labour input (AWU)	1.2	1.2	1.8	1.9	0.9	0.8	0.8	0.8	1.5	1.5
Livestock population (LU)	3.7	4.2	8.7	12.1	1.4	1.1	1.0	0.3	5.0	1.1
Standard output (thousand EUR)	12.1	15.6	26.4	38.7	6.1	7.7	3.6	2.7	13.8	5.7
Standard gross margin (thousand EUR)	6.9	8.0	14.9	18.9	3.7	4.4	2.1	1.6	7.8	3.4

Source: as in Table IV.1.

From the presented data, we can generally conclude that type A farms are development-oriented – most of them see their future in agricultural activities. Other farms of this type will either gradually shift to the population of other types of farms or become liquidated. In the first case, changes are stimulated mainly by economic relations (pressure to increase the production scale resulting from the market competition and growing remunerations in non-agricultural sectors), while in the other the point is the impossibility to cope with competition and the absence of successors. Type B farms are mostly between agricultural and non-agricultural orientation, yet the latter is more preferred while type C and D farms gradually leave agricultural activities, although some of them will be maintained for non--economic reasons: preferences (type C) or necessity (type D). Therefore, the further industrial transformation of family farming will be determined mostly by the destiny of type A and B farms, while the destiny of other types will not play any important role. This is the population of type A and B farms, where the natural production potential is concentrated, which even increases thanks to the flow of land from farms of other types. The population of type A and B farms is still huge (935 thousand), despite the decrease in the number of farms by 262 thousand in 2005-2016. In the coming years, we should expect a further decrease in the number of farms of these types mostly due to the demand for labour force on the part of non-agricultural sectors, offering usually the higher labour rate and due to the downward trend of the number of persons in farm families (following the similar trend in landless families). The speed of changes is also determined by spatial economy, urbanisation, lifestyle and culture. The way of transformation is less clear on farms of other types (C and D), which still hold 1.6 million ha of AL, including slightly more than 800 thousand ha of arable land. Type D farms are an increasingly marginal group which, for unforeseen reasons, will be still restored, but in the smaller number – until they disappear. The number of farms in this group is largely determined by social solutions and legal regulations with regard to farms and land trade. The matters are different as regards type C farms, whose number slightly decreased (by 3.8 thousand) and the area of arable land decreased as well (by 34 thousand ha) while the agricultural land area (in GAEC) increased by 248 thousand ha (this is the effect of the above-mentioned bringing of permanent grassland back to use).

From among 432.6 thousand of type C farms, in 2016, 223.4 thousand were self-supply farms, while 209.2 thousand were farms which could be defined as virtual (only statistical). This group of farms held 716 thousand ha of AL, including 696 thousand ha of AL in GAEC, of which 268 thousand ha are arable land. The livestock population in type C farms was only 133 thousand LU, of which in virtual farms – 12.6 thousand LU. The standard output volume per 1 ha of AL in type C farms was only EUR 0.78 thousand, while in self-supply farms it was EUR 0.97 thousand and in virtual farms EUR 0.59 thousand. Changes in this type of farms are underpinned by more universal phenomena (disappearance of some farms and appearance of other farms of hobby nature) and – which was of key importance in the given period – by the fact that after the accession to the European Union, Polish agriculture was covered by direct payments and agri-environmental programme. The future of this type of farms is largely dependent on the depth of "supermarket revolution" in Poland (so far, no slowdown is visible) and on, and maybe mainly on, the consumer awareness as to nutritive (and then health) values of industrial and usually anonymous food as well as food produced in own minifarms, using known methods.

2. Process of industrialisation of family farms

The process of transformation (industrialisation) of agriculture is expressed in the commercialisation of production, increase in industrial inputs, concentration of the production potential and production itself (economic power) and specialisation. The process of commercialisation is synthetically, yet insufficiently, expressed by the percentage of market-oriented farms, i.e. those that implement more than a half of products on the market (in value terms). The percentage of such farms slightly decreased – from 69.4% in 2005 to 66.9% in 2016. This is rather an unexpected result. If we ignore 205 thousand type C farms which do not produce either for the market or for own purposes (and draw benefits from payments or informal leases), the percentage of market farms increases to 78.4% which confirms the principle (Table IV.4).

Table IV.4. Family farms by production orientation and production and economic types in 2005 and 2016 (thousand)

Specification	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Total farms	1,723.8	1,398.1	526.2	428.7	670.6	506.1	432.6	428.8	94.5	34.5
Market	1,196.8	934.8	526.2	428.7	670.6	506.1	×	×	×	×
local market	279.7	244.7	84.5	65.5	130.8	135.6	49.3	35.9	15.1	7.3
Self-supply	527.0	257.7	×	×	×	×	432.6	223.2	94.5	34.5

Source: as in Table IV.1.

The number of “market” farms (i.e. type A and B) decreased by 22%, slightly more than the number of total farms (by 19%), including the decrease of type A farms by 19% and type B farms by 25%. The number of “self-supply” farms decreased by as much as 51%, of which the decrease of type C farms was by 48%[36] and of type D farms by 64%. This is the trend taking place for many years, but clearly accelerating after the market liberalisation in the period of political transformation and dissemination of great retail chains (supermarkets), bringing the variety of food products from all over the world, relatively cheap, with attractive packings and pleasant smell and taste (usually thanks to additional substances). After a period of a rather poor offer, it resulted in the fact that consumers relished products offered on the market – with the limitation of self-supply products. This was also supported or rather enforced by the processes taking place in agriculture, especially concentration and specialisation. However, noteworthy is the local market (direct sales). The number of local market farms decreased by 13% (in the population of type A farms, it decreased by 23%, type C farms – by 27% and type D farms – by 52% while in type B farms it increased by 4%). This resulted in a slight increase in the share of local market farms (from 16% to 18%) – mostly in the population of type B farms (from 20% to 27%) and type D farm (from 16% to 21%), with the decrease in the share in type C farms (from 11% to 8%) and type A farms (from 16% to 15%). The new legal regulations[37], facilitating direct sales, can help increase this form of production implementation, although this applies mostly to smaller scale production farms.

The macroeconomic data points to increasing intensification of agriculture following the accession to the European Union. The agricultural structure survey does not include data on this issue, including fixed assets, fertilisers, plant protection products and industrial feed. Changes in intensification of agricultural

[36] In this case, virtual (only statistical) farms were ignored.
[37] It refers to the Act of 16 November 2016 amending certain Acts to facilitate sale of food by farmers [Dz.U. 2016, poz. 1961 z późn. zm.].

production can be determined only indirectly using the principle consisting in the fact that with as intensification (material inputs) increases, capital intensity increases while labour-intensity of production decreases and this is reflected in the decreasing value of the ratio of value added to the production value. In the analysed population of farms, the standard output value and the standard gross margin value were determined. In the period from 2005 to 2016, the ratio of the former to the latter dropped by 5.3% (from 47.8 to 42.5) so quite a lot. In type A farms, this ratio decreased by 6.5% (from 47.1 to 40.6), which points to increasing capital intensity of production. This ratio also decreased in type B farms by 2.7% (from 50.0 to 47.8), but increased in type D farms by 2.8% (from 47.2 to 50.0) and in type C farms by 1.1% (from 50.0 to 51.1). This was the consequence of preferring quality (actual or implied) to the quantity of manufactured products. It also indicates the different trends in capital intensity of production in type A and B farms and type C and D farms.

Table IV.5. Agrarian structure of family farms in production and economic types in 2005 and 2016 (total farms by columns = 100)

Area groups (ha of AL)	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
1-5	56.9	53.7	20.2	18.2	68.2	59.4	87.0	82.7	43.9	51.6
5-25	38.7	39.4	67.6	62.2	30.7	38.4	12.9	17.0	52.1	48.2
25-50	3.4	4.6	9.2	13.0	0.8	1.5	0.1	0.3	3.4	0.1
50-100	0.8	1.6	2.2	4.5	0.2	0.5	0.0	0.1	0.5	0.1
≥100	0.3	0.7	0.8	2.0	0.1	0.2	0.0	0.0	0.1	0.0

Source: as in Table IV.1.

The concentration of the production potential and production (production scale) is the inevitable process of industrial transformation of agriculture. The concentration of the production potential is mainly expressed by the area of agricultural land and capital. The latter is not included in the studies on the agricultural structure, however, the data of agricultural censuses and farm accounting (FADN) indicates a significant and positive relationship of these categories. Therefore, it would be necessary for me to limit myself only to the area of agricultural land. The situation in this respect is well reflected by the figures in Table IV.5. Given that the agricultural land area of about 25 ha is now[38] – statistically speaking – a lower threshold of the parity farm, i.e. providing parity income, there

[38] In the face of the faster increase in income in non-agricultural sectors, obtaining parity income in agriculture requires increasing the production scale in the conditions of at least stable level of agricultural prices.

is a slow growth in the percentage of farms reaching this threshold of the parity relation primarily in type A farms (almost 1/5 of farms) and, to a much lesser extent, in type B farms (2.2% of farms). Such farms, mainly due to permanent grassland, are encountered occasionally also in the population of type C and D farms.

The situation is similar in relation to the economic power (size) of farms expressed by the standard output value. The dominance of farms with the low economic power (up to EUR 25 thousand) is clear and indicates economic weakness of family farms in Poland (Table IV.6).

Table IV.6. Structure of family farms by standard output in production and economic types in 2005 and 2016 (total farms by columns = 100)

Standard output (thousand EUR)	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
<8	62.8	65.9	22.6	22.8	77.7	75.4	77.7	96.5	47.8	79.0
8-25	25.1	14.4	43.9	23.4	19.8	16.3	19.8	3.0	38.3	18.3
25-50	8.2	10.1	22.0	25.2	2.0	6.0	2.0	0.4	10.4	2.7
50-100	3.0	7.3	8.8	21.7	0.4	1.8	0.4	0.1	2.9	0.0
≥100	0.9	2.3	2.7	6.9	0.1	0.5	0.1	0.0	0.6	0.0

Source: as in Table IV.1.

A slightly better situation is in the population of type A farms where the share of farms with the low economic power decreased from about 2/3 in 2005 to less than 1/2 in 2016. There is a progressive polarisation of farms, which portends further disappearance of economically weaker farms by the liquidation of farms and/or shifting to the population of other types. Assuming that the economic size of a viable farm should be at least EUR 50 thousand, it is easy to calculate that the number of such farms in the type A population is about 123 thousand farms. When we include farms of other types which meet this criterion (about 11 thousand), we can see that the economic viability threshold is fulfilled by about 134 thousand farms. It can, therefore, be estimated that in the next several years, the number of economically viable family farms does not exceed 150 thousand. This does not mean the liquidation of other farms, of which a significant part will function as types B and C and the increasingly narrower margin of type D farms. Some type B farms are characterised by the production and economic efficiency (which cannot be told about a large fraction of type A farms), while type D farms cannot be subject to such assessment, similarly as type C farms.

Specialisation is an integral element of the process of industrialisation of agriculture driven by the production cost mechanism. Lower unit costs of agricultural products translate into economic benefits (income, profit) that underpin the main motive of farms in the post-modern era. The specialisation promotes concentration of crops and of the size of livestock, which is essential to obtain the economies of scale of production, i.e. efficiency and profitability. In the case of crops, the specialisation is reflected in changing the structure of sowing and increasing the area of individual crops, while in the case of livestock production – in the percentage of farms keeping individual species of livestock and in the percentage of livestock in larger herds[39]. In this regard changes are relatively quick and apply to basically all crops and livestock. In general, they consist in the decrease in the number of farms with individual crops (and animals) and in the increase in the area of the given crop (herd) on the farm. Naturally, this is also determined by changes in the agrarian structure of farms.

In the case of crop production, the excessive – too deep – specialisation or monoculture relatively quickly encounters the economic and environmental constraints, while in the case of livestock production (especially industrial farms) environmental restrictions (odour, manure) and the threat of diseases are more important. These limits in the case of Polish agriculture are relatively distant, which does not mean that we should try to achieve them. The extensive specialisation and intensification lead to decreased soil fertility and increased pressure on other elements of the environment. We need to combine the advantages and disadvantages of specialisation – refer to the economics of diversity[40].

In statistics and scientific publications, we identify the so-called farming types[41] that can be used as a certain measure of changes in the specialisation of farms. The phenomenon of specialisation of farms is primarily expressed by the percentage of farms that meet the requirements of specialised farms (farming types). Table IV.7 shows the structure of farms of individual economic and production types by farming types and Figure IV.2 shows changes in this regard in 2005-2016.

The absolute increase in the number of farms took place in relation to farms specialized in field crops (I) and in permanent crops (III) – largely due to the decrease in the number of farms with mixed production: various crops (VI), various animals (VII) and mixed – with various crops and animals (VIII). The

[39] This was extensively documented in the paper by [Zegar 2018].
[40] I understand this term as economics whose economic account includes also the flows of goods and services within the farm and effects not valuated by the market, including, in particular, biodiversity.
[41] The method of classifying farms into farming types is included, *inter alia*, in the paper of [GUS 2017a, pp. 29-30].

decrease affected all economic and production types of farms. In addition, in farmers' farms (type A) there was an increase in the number of farms specialized in rearing grazing livestock (IV) and rearing granivores (V). In type B, there was only an increase in the number of farms specialized in permanent crops (III), and in type C there was an increase in the number of farms specialized in field crops (I) and in rearing animals fed on concentrated feed (V)[42]. A direct result of changes in the number of farms of individual farming types is, of course, a change in the farm structure according to these types (specialisation structure).

Table IV.7. Structure of family farms by farming types and production and economic types in 2005 and 2016 (in total by columns = 100)

Production types	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
I	40.3	56.8	22.8	34.6	54.3	70.5	44.3	66.2	20.6	31.9
II	1.6	1.6	2.8	2.9	1.3	1.7	0.6	0.4	1.1	0.2
III	2.8	4.1	3.6	6.1	3.5	5.2	1.2	1.1	0.8	0.9
IV	10.5	11.0	15.1	23.9	5.9	5.0	10.5	5.5	16.7	7.4
V	1.9	2.1	2.5	3.3	1.2	0.9	2.1	2.4	1.5	0.7
VI	3.6	3.2	3.8	3.0	3.7	3.7	3.3	3.0	2.7	2.5
VII	7.8	3.5	12.7	5.8	5.0	2.3	5.4	2.5	11.4	3.1
VIII	30.0	15.9	35.9	20.3	24.1	10.4	29.1	17.3	42.6	21.5
Not determined	1.5	1.8	0.8	0.1	1.0	0.3	3.5	1.6	2.6	31.8

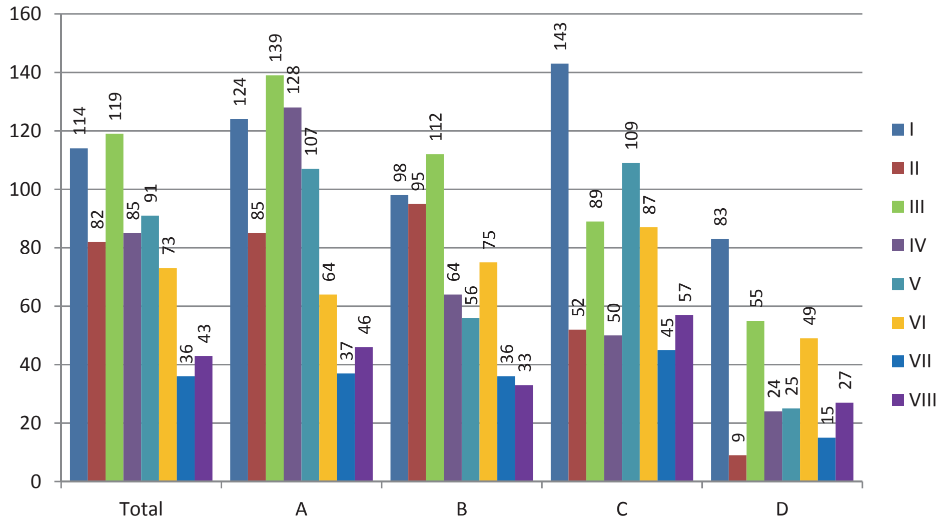
Farming types: I – specialized in field crops; II – specialized in horticultural crops; III – specialized in permanent crops; IV – specialized in rearing grazing livestock; V – specialized in rearing granivores; VI – mixed – various crops; VII – mixed – various animals; VIII – mixed – various crops and animals

Source: as in Table IV.1.

Of importance is also the percentage of farms with field crops (i.e. *a la rebours* without such crops), mixed farms (field crops and livestock) and livestock farms. A specific category of farms are farms only with permanent crops or only with permanent grassland (PG). The percentage of such farms was provided in Table IV.8. On the other hand, Figure IV.3 illustrates changes in the number of farms with the identification of selected categories.

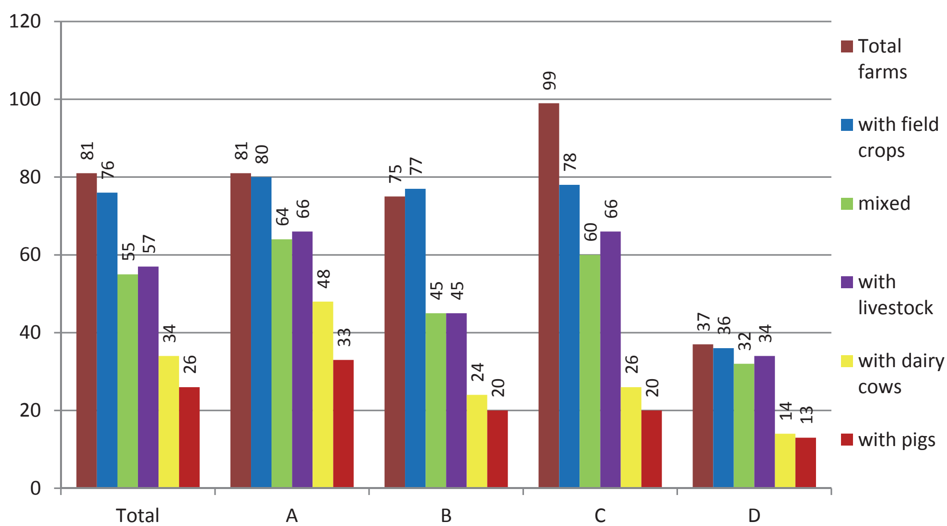
[42] This is small-scale rearing intended mainly for self-supply.

Figure IV.2. Change in the number of family farms by farming types in all farms and in identified production and economic types (%)



Source: as in Figure IV.1.

Figure IV.3. Changes in the number of family farms by production and economic types in 2005-2016 (%)



Source: as in Figure IV.1.

Table IV.8. Specific categories of family farms in production and economic types of farms in 2005 and 2016 (percentage in the total number of farms)

Percentage of farms	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Only with PG[a]	3.3	8.5	1.3	2.0	4.7	3.8	3.9	20.9	1.2	5.7
Only with permanent crops	0.9	1.8	1.3	3.1	1.1	2.0	0.2	0.3	0.1	0.1
With field crops	90.7	85.1	95.3	93.5	89.1	91.4	86.6	68.5	95.1	92.5
Mixed[b]	69.7	47.1	82.8	65.2	56.7	33.6	70.0	42.5	87.0	76.4
with livestock	72.4	51.0	83.7	67.4	58.9	35.4	75.9	50.2	88.8	83.6
cattle	43.9	24.5	64.6	49.1	29.4	13.0	35.9	12.3	68.2	39.1
dairy cows	40.9	17.4	60.7	35.9	26.9	8.4	33.3	8.8	64.6	25.0
pigs	38.8	12.3	59.5	24.3	28.3	7.6	26.7	5.3	54.2	19.2
poultry	61.1	36.0	66.8	37.3	50.8	27.4	67.3	42.9	74.2	59.7

[a] PG – permanent grassland; [b] with field crops and livestock

Source: as in Table IV.1.

Noticeable is a huge decrease in the number of farms with pigs and dairy cows which is a direct consequence of the progressive specialisation and concentration of rearing and of a decrease in natural consumption (from self--supply). This is also reflected in the decreased number of mixed farms. The number of farms with field crops decreased mainly due to bringing permanent grassland back to agricultural use (often only apparently), for obtaining area and agri-environmental payments (type C). In the population of type A and D farms, the dynamics of decrease slightly exceeded the decrease in the overall number of farms, while in the population of type B farms it was even smaller.

3. Environmental sustainability

The measurement of environmental sustainability poses many difficulties due to the complexity (composition) of indicators as well as the availability of relevant data. In the case of the analysed population, account was taken of five indicators on the share of cereals, green cover, plant groups, stocking density and balance of organic matter[43] (Table IV.9). In addition, what was indicated were some characteristics of the structure of sowings and organic farms, which are friendly to the environment and can be considered as a prospective form of agriculture.

[43] Method of calculation and "content" of these indicators are included in the publication by [Zegar and Wilk 2007; Toczyński et al. 2009; Wrzaszcz 2012; GUS 2013].

Table IV.9. Family farms[a] by production and economic types, meeting the basic criteria of environmental sustainability (%)

Percentage of farms meeting the criterion of	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Plant cover	65	61	70	64	64	61	61	57	68	65
Share of cereals	28	30	27	36	22	26	38	29	25	19
Plant groups	37	20	53	34	28	13	29	11	44	20
Balance of organic matter	55	72	68	79	51	73	42	61	63	69
Stocking density[b]	99	98	98	94	99	99	99	100	98	100
Balance of organic matter (t/ha)	0.09	0.23	0.12	0.25	0.05	0.19	-0.02	0.22	0.11	0.12
Plant cover[c]	49	53	49	53	50	53	48	53	48	51

[a] applies to farms with field crops; [b] applies to all farms – with and without field crops; [c] % of the area of field crops

Source: as in Table IV.1.

The study of the agricultural structure in 2016 also determined the percentage of farms using crop rotation on at least 75% of the total area of sowings in arable land in the population of farms with field crops. The percentage of such farms is 42.5, whereby in type A – 47.7, type B – 48.6, type C – 29.8 and type D – 43.0.

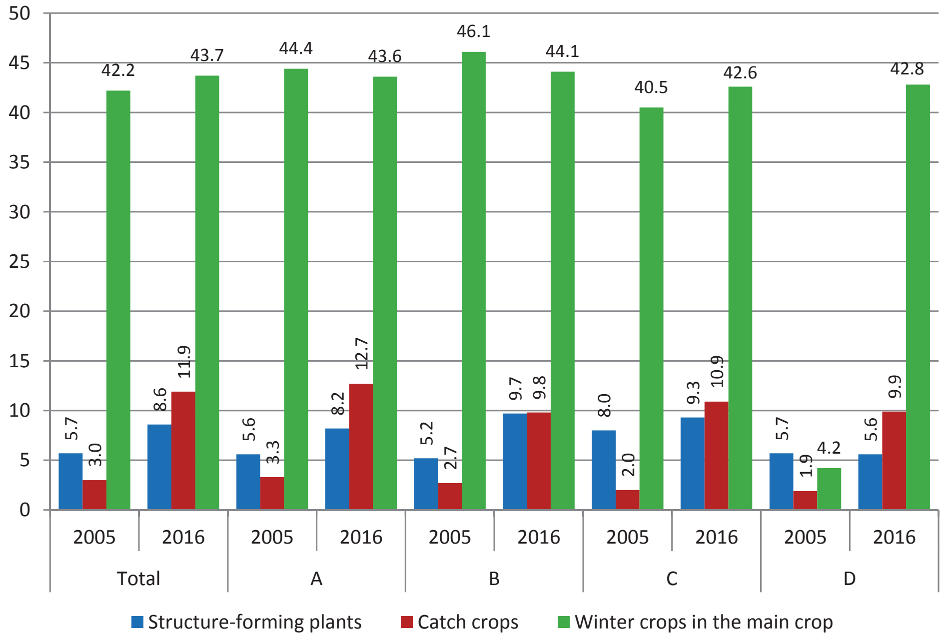
Climate change, accompanied by the increasing phenomenon of drought, increases the interest in irrigation of crops. The percentage of farm irrigating their crops is still small: in 2016, irrigation applied to 7.0% of farms[44], including 9.4% of type A, 6.8% of type B, 5.0% of type C and 6.3% of type D.

During the analysed period, changes in the percentage of farms meeting the adopted criteria of environmental sustainability are not unambiguous. Certainly, positively assessed should be the increase in the percentage of farms meeting the criterion of balance of organic matter (BOM) with a clear increase in the amount of organic matter in the soil. There was also an improvement for the criterion of the share of cereals, while the deterioration concerns the criterion of plant groups and plant (winter) cover. As regards the criterion of plant groups, it is mainly the effect of increasing specialisation; however, we can expect that the CAP "greening" instrument will bring an improvement in this regard[45]. Advancing the process of specialisation in the livestock production is the reason for the decreased percentage of farms that meet the criterion of stocking density, which is clearly visible in the case of type A farms.

[44] According to the data of the National Agricultural Census 2010 irrigation was present only in 0.6% of farms [GUS 2013, p. 173, table 3.26].
[45] See studies by [Wrzaszcz 2017].

A higher importance attached by farms to soil fertility is evidenced by the increased cultivation area of structure-forming plants in type A, B and C farms and the significantly increased area of catch crops in all types of farms. The share of winter crops in the main crop increased slightly, whereby this increase was significant in type D farms (Figure 4). These farms shifted to the cultivation of cereals, which for them was the easiest and which was reflected in the reduced percentage of farms that meet the criterion of the share of cereals that in this type is extremely low (only 19% of farms meet this criterion).

Figure IV.4. Area of sowings of structure-forming plants, catch crops and winter crops in the main crop in 2005-2016 in farms[a] by production and economic types (in % of the total area of sowings)

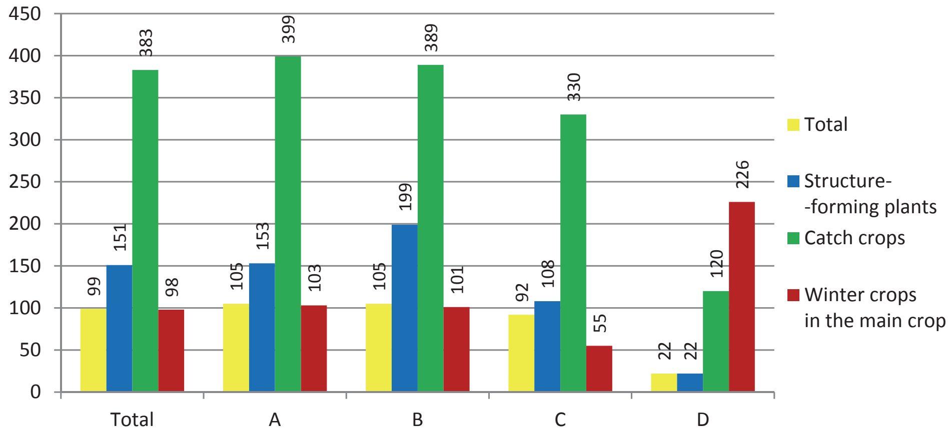


[a] applies to farms with field crops

Source: as in Figure IV.1.

When assessing changes in absolute terms, it is necessary to take account of changes in the area of sowings, which increased slightly in type A and B farms, also decreased slightly in type C farms and decreased significantly in type D farms. Noteworthy is the increased area of structure-forming plants in type A, B and C farms and a dramatic decrease in type D farms, strong increase in the area of catch crops in all types of farms and the increased area of winter crops in the main crop in type D farms (Figure IV.5).

Figure IV.5. Changes in the overall area of sowings, structure-forming plants, catch crops and winter crops in the main crop in farms[a] by production and economic types in 2005-2016 (%)



[a] applies to farms with field crops

Source: as in Figure IV.1.

The issue of fertilisation is increasingly important. This justifies, on the one hand, the obvious positive effect of fertilisation on yields and economic results of farms, and, on the other, its negative environmental impact. The latter applies to both scarce resources of energy fossils, phosphorus and potassium, as well as the impact on pollution, especially of waters, and on biodiversity. We should add here fertilisation with calcium, which in Poland is highly recommended due to excessively acidified soils. In the light of the above, of importance is the ratio of artificial fertilisers and organic fertilisers, in particular of animal origin (manure, liquid manure and slurry). The issue of fertilisers is presented for 2016 only, as the agricultural structure survey in 2005 did not gather data in this regard[46].

Table IV.10 summarises selected data on fertilisation by identified types of farms. The population of market-oriented farms is characterised by a greater percentage of farms using mineral fertilisers and organic fertilisers of animal origin. In the latter case, there is a clear correlation with the percentage of farms keeping livestock (cf. Table IV.8). The same situation is in relation to mineral and lime fertilisation. In the case of organic fertilisation (using fertilisers of animal origin), the supremacy of type A farms is obvious – it is justified by the concentration of livestock breeding, including larger herds, which explains the

[46] From the data of agricultural statistics it results that individual farms in 2004/2005 applied 93.6 kg NPK and 86.1 kg CaO per 1 ha of AL [GUS 2006b, p. 253] and in 2015/2016 127.0 kg and 65.6 kg, respectively [GUS 2017b, p. 156].

larger percentage of farms removing fertilisers of animal origin outside the farm. Only in this type of farms, the percentage of farms removing such fertilisers is higher than the percentage of farms bringing them in. The supremacy of type A farms is also visible in introducing and removing fertilisers per 1 ha (pure NPK component) and balance of fertilisers. With the highest values for introducing and removing, type A farms also achieve a significantly positive balance, while in other types of farms, on average, the balance is negative.

Table IV.10. Fertilisation on farms by production and economic types, 2016

Specification	Total	Production and economic types			
		A	B	C	D
	Percentage of farms[a]				
Applying mineral fertilisers[b]	75.9	90.7	82.2	53.5	79.1
Applying organic fertilisers of animal origin	48.1	67.2	35.7	41.6	71.1
Applying chemical plant protection products	66.1	83.9	71.3	41.6	70.6
Applying liming	10.4	18.5	9.3	3.8	7.3
Removing fertilisers of animal origin	4.2	7.2	2.3	3.0	8.1
Bringing in fertilisers of animal origin	9.3	6.8	11.3	9.6	8.4
	Absolute terms				
Mineral fertilisation (dt NPK/ha)[c]	128	150	108	48	88
Organic fertilisation (dt NPK/ha)[d]	73	100	29	18	34
Lime fertilisation (dt CaO/ha)[e]	347	348	362	266	250
Introduction of fertilisers, kg NPK/ha[d]	199	244	138	89	125
Removal of fertilisers, kg NPK/ha[d]	167	181	140	149	138
Balance of fertilisers, kg NPK/ha[d]	32	63	-2	-60	-13

[a] basis for a reference were all farms of the given type; [b] including calcium fertilisers; [c] in pure oxidic component; [d] fertilisers in elemental component; [e] in pure component on farms applying liming

Source: as in Table IV.1.

As an indicator of environmental sustainability, we may also adopt the percentage of organic farms and the area of organic crops. Due to the relatively rapid development of this form of agriculture after the accession to the EU, as we may think because of subsidies for such agriculture – and the time of shifting of farms to the organic production, certified organic farms and farms in the course of shifting have been identified. What was also determined, was the area of organic crops and the number of farms using organic methods also in the livestock production (Table IV.11).

Table IV.11. Organic farms by production and economic types in 2005 and 2016

Specification	Total	Production and economic types			
		A	B	C	D
	2005				
Certified farms with organic crops	3,036	1,350	981	456	249
Area of organic crops (ha)	49,654	31,338	12,859	2,703	2,754
Farms in the course of shifting – plant	1,091	511	324	181	76
Area of crops in the course of shifting (ha)	20,048	12,652	5,237	1,390	769
Organic methods also in livestock production	2,572	1,247	591	486	248
	2016				
Certified farms with organic crops	16,145	7,934	6,542	1,484	185
Area of organic crops (ha)	367,484	235,321	114,525	15,950	1,688
Farms in the course of shifting – plant	7,040	4,169	2,373	453	45
Area of crops in the course of shifting (ha)	74,622	51,592	20,172	2,715	143
Organic methods also in livestock production	2,613	1,512	816	220	65
	Change in 2005-2016 (%, 2005 = 100)				
Certified farms with organic crops	532	588	667	325	74
Area of organic crops (ha)	740	751	891	590	61
Farms in the course of shifting – plant	645	816	732	250	59
Area of crops in the course of shifting (ha)	372	408	385	195	19
Organic methods also in livestock production	102	121	138	45	26

Source: as in Table IV.1.

The CAP mechanisms in terms of increasing demand for food produced organically sparked interest in organic farming. In the analysed period, there has been a multiplication in the number of organic farms, both certified and those in the course of shifting – except for type D farms. In the case of farms applying organic methods also in the livestock production, the number of type A and B farms increased. In this case, interesting is the decrease in the number of type C farms, which due to the area of PG are predestined for organic farming.

Certified organic farms are significantly larger than other farms as indicated by the area of organic crops, which in the period from 2005 to 2016 increased by 39% – mostly in type C farms (by 81%), less in type B farms (by 34%) and even less in type A farms (by 28%), whereas in type D farms there was the decrease in the average area of organic crops (by 18%).

Table IV.12. Area of organic crops in organic farms in 2005 and 2016 (ha/farm)

Farms	Year	Total	Production and economic types			
			A	B	C	D
Certified	2005	16.4	23.2	13.1	5.9	11.1
	2016	22.8	29.7	17.5	10.7	9.1
In the course of shifting	2005	18.4	24.8	16.2	7.7	10.1
	2016	10.6	12.4	8.5	6.0	3.2

Source: as in Table IV.1.

The area of organic crops in 2005 was significantly greater in the case of farms in the course of shifting than in the case of certified farms, which indicates the interest of larger farms in organic production. However, in 2016 the situation changed dramatically, because, on average, the area of organic crops was more than 2 times smaller than that of certified farms (Table IV.12). Taking the area in the latter as 100, the ratio of the area of organic crops on farms in the course of shifting was as follows: total – 47, A – 42, B – 49, C – 56, D – 35.

4. Economic sustainability

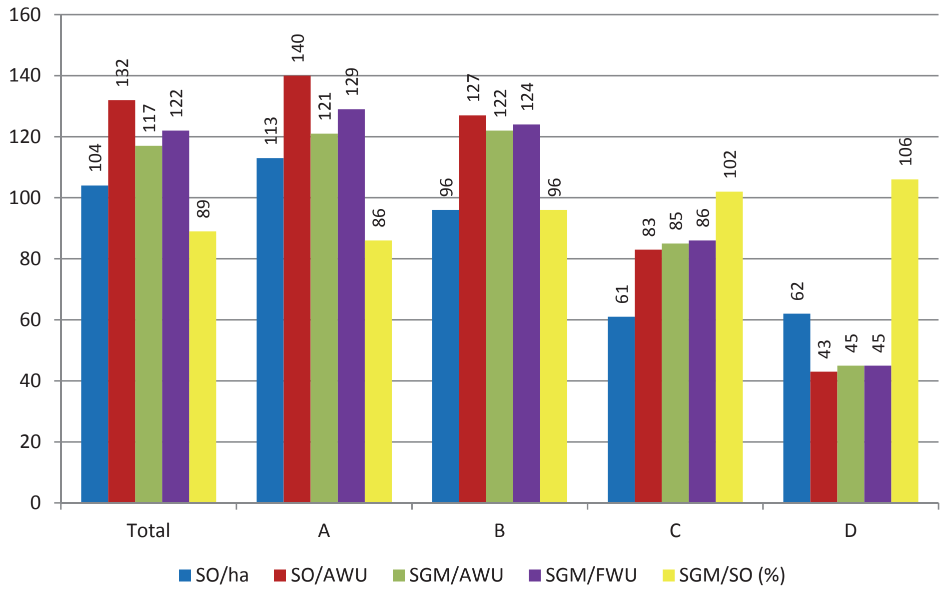
With respect to the identified types of farms, the indicators of economic sustainability (governance) include land productivity, labour efficiency and income (sources of livelihood). The land productivity in conditions of limited land resources is important for food security (an important indicator of social sustainability) and for economic results of the farm. As a basic indicator of economic sustainability, we can adopt the labour efficiency as it defines the possibilities of labour rate and then income of the farm family (household).

In the analysed period, type A farms improved the land productivity and labour efficiency. Type B farms improved the labour efficiency, which resulted mainly from reducing labour inputs by 1/4 while slightly reducing the area of agricultural land in this population of farms. Type C farms reduced both the land productivity and labour efficiency. This is the result of the orientation of farms mainly or even only towards payments arising from the CAP mechanisms. The population of type D farms underwent the greatest changes. The size of this population of farms decreased by almost 1/3, just like labour inputs. The area of agricultural land decreased by 1/4, the livestock population decreased by as many as 13 times and the standard output volume – 7 times.

Therefore, only the economically weakest farms were left there, while some stronger farms shifted to the population of type C farms and some were liquidated mostly for demographic reasons. On the other hand, the change in the ratio of standard gross margin to standard output seems to be quite peculiar –

it decreased the most in type A farms, less in type B farms, while it increased in type C farms and even more in type D farms (Figure IV.6). This is the aftermath of the above indicated changes in capital intensity of agricultural production (Table IV.13).

Figure IV.6. Changes in economic relations of farms by production and economic types in 2005-2016 (%)



Source: as in Figure IV.1.

Table IV.13. Economic relations of farms by production and economic types in 2005 and 2016 (thousand EUR)

Specification	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
SO/ha	1.59	1.66	1.76	1.98	1.26	1.21	1.32	0.81	1.69	1.05
SO/AWU	10.23	13.50	14.53	20.32	7.13	9.08	4.27	3.55	9.00	3.87
SGM/AWU	5.87	6.89	8.21	9.90	4.28	5.22	2.56	2.18	5.10	2.32
SGM/FWU	6.16	7.52	8.82	11.38	4.43	5.50	2.60	2.23	5.22	2.36
SGM/SO (%)	57.4	51.0	56.5	48.7	60.0	57.4	60.0	61.4	56.7	60.0

SO – standard output; AWU – annual work unit; FWU – family work unit; SGM – standard gross margin

Source: as in Table IV.1.

The agricultural structure survey carried out by the CSO does not contain the information about income from agricultural activities. Indirectly, this income is approximately indicated by standard gross margin and a source of dominant income of the household. Income from agricultural activities (on the farm, on own account) is, by definition, a dominant (primary) source of livelihood in type A and D farms. However, those farms also gain income from other sources, whereby the percentage of such farm increases – in type A farms it is almost 50%, and in type D farms it exceeds 50% (Table IV.14). This phenomenon also occurs in the developed countries, including the United States.

Table IV.14. Family farms with non-agricultural income by production and economic types of farms

Specification	Total		Production and economic types							
			A		B		C		D	
	in % of all farms by columns									
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Total	76.4	82.2	34.6	46.6	100.0	100.0	100.0	99.2	33.8	51.4
from:										
non-agricultural activities	9.2	15.2	4.2	7.1	13.5	20.6	9.9	17.7	3.4	8.6
paid labour	40.2	47.8	11.6	20.3	58.3	65.1	52.8	57.3	12.9	18.8
pensions and annuities	38.8	33.1	19.6	20.4	44.9	35.0	57.3	44.0	17.5	24.6
other unearned income	4.4	7.6	2.6	4.8	4.6	8.0	6.1	9.9	4.2	8.2

Source: as in Table IV.1.

5. Social sustainability

The social sustainability indicators are a large mosaic which differs as to the assessment of suitability. The most important include indicators on people or, as it is defined in economic jargon, the human factor. On farms – in their functioning and development – the point is, above all, the characteristics of users (managers) of farms: gender, age and education. Then, the point is the involvement of household members on the farm and total labour inputs consumed on the farm. The important social sustainability indicators relate to the farm's link with the environment both in the production sense (in the market sense – in particular, sales on the local market), and a contribution to the viability of rural localities. The agricultural structure survey does not include information on this topic. Indirectly, it can be concluded through the prism of non-agricultural activities, especially activities based on the farm assets (related to such farm).

Management of the farm is no longer the domain of men, as a growing percentage of users are women. This, in particular, applies to hobby farms (type C), and to the lowest extent the farmers' farms, however, even among them nearly every fifth farm is managed by a woman. Reducing the degree of masculinisation and intensifying feminisation also covers agriculture, just like it covered other professions (activities). This is illustrated by the figures in Table IV.15.

Table IV.15. Selected characteristics of users on family farms by production and economic types in 2005 and 2016 (%)

Specification	Total		Production and economic types							
			A		B		C		D	
	in % of all farms by columns									
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Total users	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
men	72.0	68.9	84.1	81.8	68.3	66.3	61.8	58.9	77.9	69.3
women	28.0	31.1	15.9	18.2	31.7	33.7	38.2	41.1	22.1	30.7
< 44 years	39.8	33.3	47.1	36.0	38.7	35.4	32.0	28.1	42.9	29.2
45-64 years	48.0	55.2	49.7	59.7	47.1	52.5	46.5	53.4	52.0	63.3
≥ 65 years	12.2	11.5	3.2	4.3	14.2	12.1	21.5	18.5	5.1	7.5

Source: as in Table IV.1.

As regards the age of users of farms, the aging process is in progress, which is expressed by shifting users from the young group to the slightly older group, while the social security system clearly limited the percentage of users of older (retirement) age. In this regard, characteristic is the population of hobby farms (type C), where, in many cases, retirees kept the farm, having no successors or persons willing to take over the farm and complementing the usually modest social benefit (pension or annuity). In this type, this applies to almost 1/5 farms, which points to the liquidation of such farms in the close future. To a lesser extent, this also applies to auxiliary farms (type B).

With regard to the educational background of users (managers) of farms, a lot has changed. The drive for learning after the accession was and still is significant. This applies, in particular, to general education, because usually young people from farm families (more precisely, from households with farm user) are mostly oriented towards work outside agriculture, while the profession of a farmer is not attractive for them. However, family considerations (successors with general higher education) and probably other considerations are reasons for which relatively a lot of auxiliary farms and hobby farms (type B and C) are managed by persons with such education. Low agricultural taxes and direct payments support this approach. In the case of farmers' farms (type A), the percentage of users with general higher education increased 3.4 times and with agricultural higher education – 3.1 times. In general, every ninth farmers' farm is managed by a user with higher education, but only every twenty-eighth is managed by a user with agricultural higher education (Table IV.16).

Table IV.16. Structure of users of family farms by general and agricultural education and by production and economic types in 2005 and 2016

Specification	Total		Production and economic types							
			A		B		C		D	
	in % of all users of farms by columns									
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
	General education									
Higher	5.1	13.1	2.4	8.2	8.3	17.4	4.3	13.8	1.2	2.3
Post-secondary and secondary vocational	22.6	31.9	20.9	33.2	25.8	33.8	21.0	29.1	16.2	23.4
Secondary general	4.6	5.1	3.8	3.4	5.3	6.0	4.6	6.0	4.5	3.7
Secondary vocational	39.5	37.1	45.4	42.2	35.8	32.8	36.6	36.1	45.6	49.6
Lower secondary, elementary	24.2	11.9	24.5	12.4	20.6	9.4	28.2	13.8	29.4	19.5
Elementary, not completed	4.0	0.8	3.0	0.7	4.3	0.6	5.2	1.2	3.2	1.6
	Agricultural education									
Higher	1.4	2.7	1.4	3.5	1.8	3.1	0.8	1.5	0.4	0.7
Post-secondary and secondary vocational	7.9	12.5	12.2	20.5	6.8	10.9	4.2	6.8	7.7	8.6
Basic vocational	11.3	12.2	20.8	21.6	7.1	8.4	5.5	7.0	15.7	14.4
Agricultural course	25.8	17.4	29.9	18.5	24.3	16.3	22.7	17.0	27.9	21.9
No agricultural education	53.7	55.3	35.8	35.9	59.9	61.3	66.8	67.7	48.3	54.3

Source: as in Table IV.1.

We should expect the further increase in the percentage of users with agricultural education for farmers' farms. There is the resultant of two trends: the disappearance from this population of economically weaker farms, usually with the lower level of education and the strive for professionalization of the profession of a farmer through agricultural higher education.

As regards the structure of family labour inputs, a masculinisation trend takes place – as opposed to users. Probably this is due to the fact that, usually, the sons rather stay on the farm than daughters, as daughters are less attracted by on-farm work to the benefit of a more attractive (not necessarily financially) off--farm work (less burdensome, with higher prestige, making it easier to establish contacts, including finding a husband). As in the case of users, there is the process of aging of those working on farms. Generally, however, the percentage of younger persons working on the farm (< 44 years) is relatively high, while the relatively high percentage of elderly workers (65 years or more) is in auxiliary and hobby farms (Table IV.17).

Table IV.17. Labour factor on family farms by production and economic types of farms

Specification	Total		Production and economic types							
			A		B		C		D	
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
	Percentage in labour inputs (AWU)[a]									
Family	95.3	91.6	93.1	87.0	96.5	94.9	98.5	97.9	97.8	98.5
Permanent paid workers	0.8	4.6	1.4	7.9	0.4	1.8	0.1	0.7	0.3	0.2
Casual paid workers	3.0	2.7	4.7	4.3	2.2	1.7	0.7	0.3	1.3	0.6
Neighbours' assistance	0.7	0.8	0.7	0.6	0.7	1.2	0.6	0.9	0.6	0.6
	Percentage of family members working on the farm									
Men	53.9	56.2	55.7	57.6	53.9	56.7	51.2	53.9	55.3	57.1
Women	46.1	43.8	44.3	42.4	46.1	43.3	48.8	46.1	44.7	42.9
< 44 years	48.4	43.1	55.6	47.8	45.3	42.9	42.3	38.0	53.7	41.6
45-64 years	39.7	44.9	38.3	45.4	40.9	44.1	39.9	44.9	39.3	49.5
≥ 65 years	11.9	12.0	6.1	6.8	13.8	13.0	17.8	17.1	7.0	8.9
Working on the farm only	68.6	98.7	88.5	99.3	54.1	98.2	59.7	98.6	86.2	99.5

[a] complemented to 100% by the so-called contract workers

Source: as in Table IV.1.

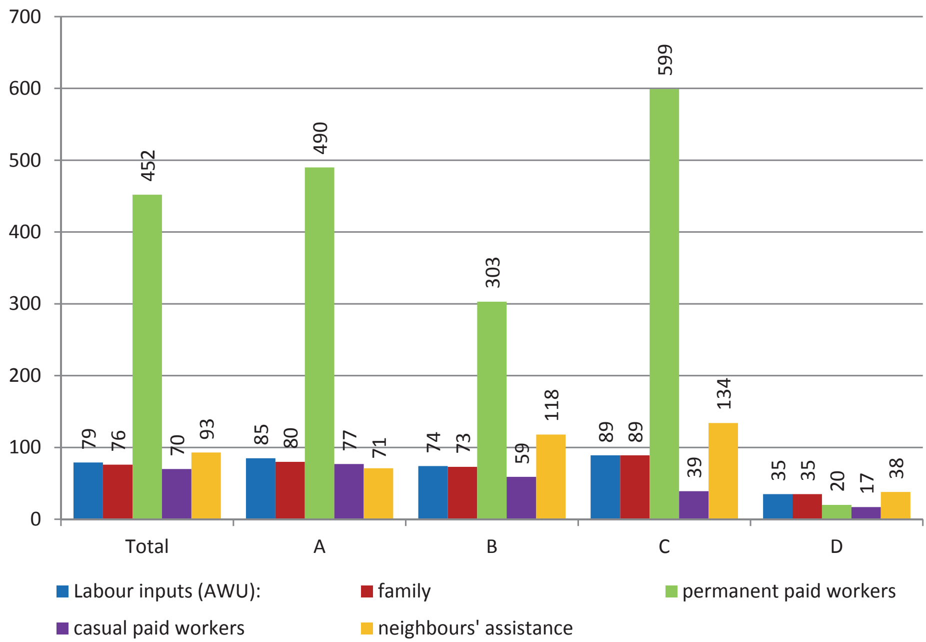
The analysed population of farms is dominated by family work in labour inputs with a slight downward trend, more visible in type A farms, as it is there where the processes of concentration and specialisation are most advanced (Figure IV.7). Noticeable is a trend to increase the share of permanent paid labour in type A farms, where this paid labour is almost 8%. This may mean that some farms of this type assume the features of capitalist enterprises[47].

After many years of decline as regards permanent paid workers, the importance of this form of employment is growing again. The demand increases along with concentration and specialisation, while the difficulties with obtaining seasonal workers are growing. Agricultural technology is not completely able to replace human labour, while more and more sophisticated tractors, combines and farm machinery require skills and responsibilities beyond the skills of casual (seasonal) workers. This results in the different dynamics and change in the pro-

[47] There are about 23 thousand of such farms – mainly in type A.

portion of permanent and seasonal paid workers. The number of permanent paid workers increased from 14.8 thousand of individuals in 2005 to 70.6 thousand in 2016. Most of these workers are concentrated in type A farms (in 2005 – 77.7%, 2016 – 84.2%).

Figure IV.7. Dynamics of labour inputs on family farms by production and economic types in 2005-2016 (%)



Source: based on the data as in Figure IV.1.

A characteristic feature of the industrial stage of development of family farming – even with most developed countries with large farms – is the multi-functional nature of families using the farm and, consequently, the diversity of sources of income. This is taking place despite the decreasing number of people in the average farm family. In the case of Poland, in the analysed period there was a reverse phenomenon. The percentage of farms with non-agricultural activities, small even in 2005, has decreased. The increase took place only in relation to agritourism and renewable energy production (Table IV.18). It may be believed that the decline in the percentage of farms engaged in processing agricultural products will be inverted after introducing the less rigorous conditions and facilities in direct sales. The development of non-agricultural activities in particular on a basis of the farm assets is very important for the rural labour market, sources of income and, in general, the viability of rural localities.

Table IV.18. Family farms with non-agricultural activities[a] by production and economic types of farms

Specification	Total		Production and economic types							
			A		B		C		D	
	in % of all farms by columns									
	2005	2016	2005	2016	2005	2016	2005	2016	2005	2016
Number of farms	100	100	100	100	100	100	100	100	100	100
Farms with non-agricultural activities in total	6,21	2,84	3,23	2,04	8,80	3,24	6,58	3,25	2,74	1,84
- agritourism	0,47	0,76	0,21	0,38	0,59	0,82	0,63	1,08	0,45	0,41
- crafts	0,10	0,10	0,06	0,03	0,13	0,11	0,11	0,16	0,01	0,04
- processing of agricultural products	0,26	0,19	0,13	0,13	0,41	0,30	0,20	0,12	0,12	0,13
- renewable energy production	0,02	0,03	0,01	0,04	0,01	0,02	0,04	0,01	0,01	0,00
- aquaculture	0,70	0,07	0,91	0,07	0,72	0,08	0,44	0,04	0,61	0,04
- services	1,56	0,27	0,87	0,58	2,12	0,19	1,70	0,07	0,82	0,18
- other	3,34	1,56	1,16	0,92	5,18	1,88	3,69	1,86	0,83	1,06

[a] activities directly related to the farm

Source: as in Table IV.1.

***

Family farms are a very diverse population (mosaic) due to different characteristics. This should be perceived as an advantage – as a factor determining the efficiency and development of family farms, including the growing production and economic potential of some farms, declining potential of other farms, and liquidation of yet other farms. The presented paper showed the diversity of family farms in Poland in terms of two characteristics: dominant way of implementing produced agricultural products (market, self-supply) and dominant source of livelihood of the household (family). This allowed to identify four production and economic types of family farms: farmers' farms (type A), auxiliary farms (type B), hobby farms (type C) and traditional farms (type D). Building on the results of the agricultural structure surveys carried out by the CSO in 2005 and 2016, we determined the values of basic characteristics of the identified types of farms and changes in this period, i.e. in fact, changes after the accession of Poland to the European Union and covering Polish agriculture with CAP mechanisms. The analysis was basically limited to the issue of sustainability of family farms.

The production and economic potential of family farms in the period after the accession (in 2005-2016) changed in accordance with the principles of industrial transformation of agriculture, which took place in more developed countries and also takes place now in less developed countries. The number of farms decreased in all types, with the growing production and economic importance of type A farms. The result of the current socio-economic development of Poland, including agriculture, is the relatively large share of other types production and economic types – in relation to the production.

Of particular interest to the agricultural policy should be type A and B farms – sensitive to agricultural policy instruments – as they gather the environmental potential and their production addressed to the market has a significant impact on food security of the country. These farms are subject to the requirements of market competition, which makes them boost the production scale and reduce unit costs. At the same time, increasing remunerations in the non--agricultural sectors also constitute growing aspirations as to farm income (labour rate). Therefore, the pace of transformation in the population of farms of these types (especially type A) is determined by the increase of non-agricultural remunerations, caused by the declining demand in the labour market (the consequence of the declining birth rate, aging population and emigration), which forces reaching out to labour resources in farm families. Under these conditions, the concentration of family farms (farmers) stimulated by competition and the growth of non-agricultural remunerations (income) faces the rising remunerations for paid labour, rising costs of agricultural technology (rising energy prices), decreasing labour resources of farm families (decreasing number of people in the family) and the growing aspirations and life attitudes of the younger generation, including possible successors of farms.

The picture of changes in the sustainability of family farms is not unambiguous. Pressure on industrial transformation of farms is substantial and has the environmental impact. This applies, in particular, to the increased consumption of chemical fertilisers, plant protection products, as well as to the increased herd of livestock (which entails the use of antibiotics and other medicines for animals). Positive is the increase in the content of organic matter in the soil and the increase in the area of arable land with the winter plant cover. Unequivocal and visible is the impact of the CAP instruments in the development of organic farms, although they are still a margin.

With regard to the economic sustainability of family farms, progress is expressed in the increased land productivity and even more in the increased labour productivity (mainly by reducing labour inputs involved in agriculture) and in increased agricultural income (mainly thanks to direct payments). The land productivity increased only in type A farms, while the labour productivity in type A and B farms. This indicates a growing gap in this regard between farmers' farms and other types of family farms. In relation to income, despite increased farm income, there was an increase in the percentage of farms having income from other sources, in particular from paid labour, and this applied to all types of farms.

With regard to the social sustainability, undoubtable progress has been made in terms of education of farm users, especially higher education. This very positive phenomenon occurred in all types of farms. On the other hand, there is the growing phenomenon of feminisation and ageing of farm users, while as regards the family labour inputs the phenomenon of masculinisation is observed. It can be concluded that, as yet, it does not have a significant impact on change in the sustainability of farms. A negative assessment should be given to a clear decrease in the percentage of farms with non-agricultural activities directly related to the farm. Positive is the increase in the percentage of farms with rural tourism and renewable energy production, while negative is the decrease in the percentage of farms with aquaculture, processing of agricultural products and crafts. On the other hand, the decreased percentage of farms with agricultural services (the aftermath of withdrawal of many small farms from agricultural activities) and contractual work should be assessed ambiguously.

Summing up, changes in the sustainability of family farms are not unambiguous – in some areas they deserve a positive assessment, while in others we should assess them negatively.

References

CHAPTER I: FOOD SYSTEMS AND SUSTAINABLE FOOD SYSTEMS

Bombol M. (2006), *Zachowania konsumenta na rynku* [in:] *Konsument i konsumpcja we współczesnej gospodarce*, eds. M. Janoś-Kresło and B. Mróz, SGGW, Warszawa, p. 164.

Caspi C.E., Sorensen G., Subramanian S.V., Kawachi I. (2012), *The local food environment and diet: a systematic review*, "Health & Place", Vol. 18, Issue 5, pp. 1172-1187, DOI: 10.1016/j.healthplace.2012.05.006.

Chase L., Grubinger V. (2014), Food, farms and community: Exploring Food Systems, University of New Hampshire Press, Durham, New Hampshire [https://www.amazon.com/Food-Farms-Community-Exploring-Systems-ebook/dp/B00PYX3BJK].

Davegos H., Hansman H. (2001), *Towards a consumer images approach – exploring the quirks of modern food consumer behaviour* [in:] *Food, Nature and Society: Rural Life in Late Modernity*, Ashgate, Aldershot, pp. 143-150.

Dutch Cabinet (2015), *Food agenda: for safe, healthy and sustainable food*.

Dutch Lower House 2014-2015, 32793, No. 162.

EC Preparatory Study on Food Waste (2011) [http://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf].

European Commission (2013), Report From the Commission to the European Parliament, the Council and the European Economic and Social Committee. Agricultural Genetic Resources – from conservation to sustainable use, 838 Final, Brussels.

Falkowski A., Tyszka T. (2001), *Psychologia zachowań konsumenckich*, Gdańskie Wydawnictwo Psychologiczne, Gdańsk.

FAO (2013), *The State of Food and Agriculture. Food Systems for Better Nutrition*, Rome, p. 3.

FAO (2011), *Global food losses and food waste – Extent, causes and prevention*, Rome.

FUSIONS (2016), *Estimates of European food waste levels*, IVL Swedish Environmental Research Institute, Stockholm.

FUSIONS EU data set 2015 [http://eu-fusions.org/index.php/publications].

Goszczyński W. (2014), *Smak zmiany. Nowe formy społecznej organizacji rolnictwa i konsumpcji żywności w Unii Europejskiej*, Wydawnictwo Naukowe SCHOLAR, Warszawa, p. 129.

Hawkes C., Smith T.G., Jewell J., Wardle J., Hammond R.A., Friel S., Thow A.M., Kain J. (2015), *Smart food policies for obesity prevention*, "The Lancet", Vol. 385, Issue 9985, pp. 2410-2421, DOI: 10.1016/S0140-6736(14)61745-1.

Health Council of the Netherlands (2011), *Guidelines for a healthy diet: the ecological perspective*, No. 2011/08E, Hague.

Herforth A., Ahmed S. (2015), *The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions*, "Food Security", Vol. 7, Issue 3, pp. 505-552, DOI: 10.1007/s12571-015-0455-8.

HLPE (2017), *Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*, Rome, p. 35.

HLPE (2014), *Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*, Rome, p. 12.

http://thinkeatsave.org/index.php/be-informed/definition-of-food-loss-and-waste.

Jeżewska-Zychowicz M., Babicz-Zielińska E., Laskowski W. (2009), *Konsument na rynku nowej żywności*, SGGW, Warszawa.

Komisja Europejska (2013), Komunikat Komisji do Parlamentu Europejskiego i Rady, Europejskiego Komitetu Ekonomiczno-Społecznego i Komitetu Regionów. Strategia UE w zakresie przystosowania się do zmiany klimatu, 216 final, Bruksela.

Kotecki A. (2015), *Dokąd zmierza agronomia w Polsce*, "Fragmenta Agronomica", Vol. 32, No. 4.

Kuś J., Fotyma M. (1992), *Stan i perspektywy rolnictwa ekologicznego*, "Fragmenta Agronomica", Vol. 9, No. 2.

Krzyżanowski J.T., Kowalczyk S., Kwasek M. (2018), *Z badań nad rolnictwem społecznie zrównoważonym* [47]. *Zrównoważone systemy rolnicze*, red. naukowa M. Kwasek, Monografie Programu Wieloletniego 2015-2019, nr 83, IERiGŻ-PIB, Warszawa.

Mahendra A., Polsky J.Y., Robitaille É., Lefebvre M., McBrien T., Minaker L.M. (2017), *Geographic retail food environment measures for use in public health*, "Health Promotion and Chronic Disease Prevention in Canada. Research, Policy and Practice", Vol. 37, No. 10, pp. 367-362, DOI: 10.24095/hpcdp.37.10.06.

Matysik-Pejas R., Cieślik J., Borecka A., Sowula-Skrzyńska E. (2017), *Lokalne systemy żywnościowe i ich znaczenie dla obszarów wiejskich*, "Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu", tom XIX, z. 5, DOI:10.5604/01.3001.0010.6223.

Ministerstwo Rozwoju, Agenda 2030 na rzecz zrównoważonego rozwoju – implementacja w Polsce [http://odpowiedzialnybiznes.pl/publikacje/agenda-2030-rzecz-zrownowazonego-rozwoju-implementacja-polsce/].

Oosterveer P., Guivant J., Spaargaren G. (2007), *Shopping for green food in globalizing supermarkets: Sustainability at the consumption junction* [in:] *Handbook of Environment and Society*, eds. J. Pretty, A. Ball, T. Benton, J. Guivant, D. R Lee, D. Orr and M. Pfeffer, Sage, London.

Opinia Europejskiego Komitetu Ekonomiczno-Społecznego w sprawie bardziej zrównoważonych systemów żywnościowych [Dz. Urz. UE, 19.08.2016, C 303/64].

Pimentel D., Pimentel M. (2003), *Sustainability of meat-based and plant-based diets and the environment*, "American Journal of Clinical Nutrition", No. 78(suppl), pp. 660S-663S, DOI: 10.1093/ajcn/78.3.660S.

Roberto C.A., Swinburn B., Hawkes C., Huang T.T-K., Costa S., Ashe M., Zwicker L., Cawley J.H. , Brownell K.D. (2015), *Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking*, "Lancet", Vol. 385, Issue 9985, pp. 2400-2409, DOI: 10.1016/S0140-6736(14)61744-X.

Rozporządzenie Parlamentu Europejskiego i Rady (WE) nr 1069/2009 z dnia 21 października 2009 r. określające przepisy sanitarne dotyczące produktów ubocznych pochodzenia zwierzęcego, nieprzeznaczonych do spożycia przez ludzi, i uchylające rozporządzenie (WE) nr 1774/2002 (rozporządzenie o produktach ubocznych pochodzenia zwierzęcego) [Dz. Urz. UE z 14.11.2009, L 300/1].

Smoleń S. (2013), *Nowatorskie badania – biofortyfikacja roślin w jod*, Katedra Uprawy Roli i Nawożenia Roślin Ogrodniczych, Wydział Ogrodniczy, Uniwersytet Rolniczy w Krakowie [http://wo.ur.krakow.pl/zasoby/6/2013-02-14%20Biofortyfikacja%20roslin%20w%20jod.pdf].

Swinburn B., Dominick C., Vandevijvere S. (2014), *Benchmarking food environments: experts' assessments of policy gaps and priorities for the New Zealand Government*, University of Auckland, pp. 804-814.

Swinburn B.A., Sacks G., Hall K.D., McPherson K., Finegood D.T., Moodie M., Gortmaker S.L. (2011), *The global obesity pandemic: shaped by global drivers and local environments*, "Lancet", Vol. 378, Issue 9793, pp. 804-814.

Traktat o funkcjonowaniu Unii Europejskiej [Dz. Urz. UE, 26.10.2012, C 326/47].

WHO (2015), Global Health Observatory (GHO) data [http://www.who.int/gho/ncd/risk_factors/obesity_text/en/].

WRR (2016), *Towards a food policy*, The Netherlands Scientific Council for Government Policy, Hague.

Żelazna K., Kowalczuk I., Mikuta B. (2002), *Ekonomika konsumpcji. Elementy teorii*, SGGW, Warszawa.

Żywność, zdrowie i zrównoważone rolnictwo. Nasze wybory wpływają na nas i planetę [https://www.ekonsument.pl/a66815_zywnosc_zdrowie_i_zrownowazone_rolnictwo_nasze_wybory_wplywaja_na_nas_i_planete.html].

CHAPTER II: NON-INDUSTRIAL SUSTAINABLE INTENSIFICATION OF AGRICULTURE

Abberton M., Batley J., Bentley A., Bryant J., Cai H., Cockram J., Costa de Oliveira A., Cseke L.J., Dempewolf H., De Pace C., Edwards D., Gepts P., Greenland A., Hall A.E., Henry R., Hori K., Howe G.T., Hughes S., Humphreys M., Lightfoot D., Marshall A., Mayes S., Nguyen H.T., Ogbonnaya F.C., Ortiz R., Paterson A.H., Tuberosa R., Valliyodan B., Varshney R.K., Yano M. (2015), *Global agricultural intensification during climate change: a role for genomics*, "Plant Biotechnology Journal", Vol. 14, Issue 4, pp. 1095-1098, DOI: 10.1111/pbi.12467.

Alexandratos N., Bruinsma J. (2012), *World agriculture towards 2030/2050. The 2012 revision*, ESA Working Paper, No. 12-03, FAO, Rome, p. 160.

Allouche J. (2011), *The sustainability and resilience of global water and food systems: political analysis of the interplay between security, resource scarcity, political systems and global trade*, "Food Policy", Vol. 36, pp. 3-8.

Altieri M.A. (1989), *Agroecology: A new research and development paradigm for world agriculture*, "Agriculture Ecosystems and Environment", Vol. 27, pp. 37-46.

Antonkiewicz J., Łabętowicz J. (2017), *Innowacje chemiczne w odżywianiu roślin od starożytnej Grecji i Rzymu po czasy najnowsze*, “Annales UMCS, Agricultura”, Vol. LXXII (1), pp. 1-18, DOI: 10.24326/as.2017.1.1.

Bensin B.M. (1930), *Possibilities for international co-operation in agroecological investigations. The International Review of Agriculture*, Part I: Monthy Bulletion of Agriculture Science and Practice, XXI (8), pp. 279-280.

Berg G., Mahnert A., Moissl-Eichinger C. (2014), *Beneficial effects of plant-associated microbes on indoor microbiomes and human health?* “Frontiers in Microbiology”, Vol. 5, Issue 15, pp. 1-15, DOI: 10.3389/fmicb.2014.00015.

Beus C.E., Dunlap R.E. (1990), *Conventional versus Alternative Agriculture: The Paradigmatic Roots of the Debate*, “Rural sociology”, Vol. 55, Issue 4, pp. 590-616.

Birch P.R.J., Bryan G., Fenton B., Gilroy E.M., Hein I., Jones J.T., Prashar A., Taylor M.A., Torrance L., Toth I.K. (2012), *Crops that feed the world 8: Potato: are the trends of increased global production sustainable?* “Food Security”, Vol. 4, Issue 4, pp. 477-508, DOI: 10.1007/s12571-012-0220-1.

Bommarco R., Kleijn D., Potts S.G. (2013), *Ecological intensification: harnessing ecosystem services for food security*, “Trends in Ecology & Evolution”, Vol. 28, Issue 4, pp. 230-238.

Bonny S. (2011), *Ecologically intensive agriculture: Nature and challenges*, “Cahiers Agricultures”, Vol. 20, Issue 6, pp. 451-462, DOI: 10.1684/agr.2011.0526.

Borrás S., Edler J. (2014), *Introduction: On Governance, Systems and Change* [in:] *The Governance of Socio-Technical Systems. Explaining Change*, eds. S. Borrás and J. Edler, Edward Elgar Publishing, pp. 1-22, DOI: 10.4337/9781784710194. 00010.

Brookfield H. (2001), *Intensification, and Alternative Approaches to Agricultural Change*, “Asia Pacific Viewpoint”, Vol. 42, Issue 2-3, pp. 181-192, DOI:10.1111/1467-8373.00143 .

Busby P.E., Soman C., Wagner M.R., Friesen M.L., Kremer J., Bennett A., Eisen J.A., Morsy M., Leach J.E., Dangl J.L. (2017), *Research priorities for harnessing plant microbiomes in sustainable agriculture*, “PLoS Biology”, Vol. 15, Issue 3, DOI: 10.1371/journal.pbio.2001793.

Caporali F. (2010), *Agroecology as a transdisciplinary science for a sustainable agriculture* [in:] *Biodiversity, biofuels, agroforestry and conservation agriculture*, ed. E. Lichtfouse, Springer, Dordrecht, pp. 1-71.

CCRP (2013), *Agroecological intensification*, McKnight Foundation.

Chevassus B., Griffon M. (2008), *La nouvelle modernité: une agriculture productive à haute valeur écologique*, Déméter: Economie et Stratégies Agricoles, Paris, pp. 7-48.

Clapp J. (2009), *Food Price Volatility and Vulnerability in the Global South: considering the global economic context*, “Third World Quarterly”, Vol. 30, No. 6, pp. 1183-1196, DOI: 10.1080/01436590903037481.

Clapp J., Scott C. (2018), *The Global Environmental Politics of Food*, “Global Environmental Politics”, Vol. 18, Issue 2, pp. 1-11.

Clements D.R., Shrestha A. (2004), *New Dimensions in Agroecology for Developing a Biological Approach to Crop Production* [in:] *New dimensions in agroecology*, eds. D.R. Clements and A. Shrestha, Food Products Press, Binhamton, pp. 1-20.

Czyżewski A., Henisz-Matuszczak A. (2005), *Makroekonomiczne uwarunkowania rolnictwa industrialnego i społecznie zrównoważonego. Refleksje na temat sprzężeń regulacyjnych i realnych* [in:] *Koncepcja badań nad rolnictwem społecznie zrównoważonym*, ed. J.St. Zegar, Program Wieloletni 2005-2009, No. 11, IERiGŻ-PIB, Warszawa, pp. 53-72.

Duru M., Therond O., Fares M. (2015), *Designing agroecological transitions: A review*, "Agronomy for Sustainable Development", Vol. 35, Issue 4, pp. 1237-1257, DOI: 10.1007/s13593-015-0318-x.

EPSO (2017), *Workshop on Plants and Microbiomes* – Report and recommendations, Viena 23.02.

FAO (2014), *Agroecology for Food Security and Nutrition Proceedings*, FAO International Symposium, 18-19 September, Rome.

FAO (2009), *Global agriculture towards 2050*, High-Level Expert Forum "How to Feed the World 2050" [http://www.fao.org.fileadmin/user_upload/lon/HLEF 2050_Global_Agriculture.pdf].

Fedoroff N.V., Battisti D.S., Beachy R.N., Cooper P.J.M., Fischhoff D.A., Hodges C.N., Knauf V.C., Lobell D., Mazur B.J., Molden D., Reynolds M.P., Ronald P.C., Rosegrant M.W., Sanchez P.A., Vonshak A., Zhu J.K. (2010), *Radically Rethinking Agriculture for the 21st Century*, "Science", Vol. 327(5967), pp. 833-834, DOI: 10.1126/science.1186834.

Fiedor B. (2006), *Antropologiczne podstawy koncepcji zrównoważonego rozwoju z perspektywy ekonomicznej: od homo oeconomicus do homo sustines*, "Prace Naukowe Akademii Ekonomicznej we Wrocławiu", No. 1131, pp. 104-119.

Foley J.A., Ramankutty N., Brauman K.A., Cassidy E.S., Gerber J.S., Johnston M., Mueller N.D., O'Connell C., Ray D.K., West P.C., Balzer C., Bennett E.M, Carpenter S.R., Hill J., Monfreda C., Polasky S., Rockström J., Sheehan J., Siebert S., Tilman D., Zaks D.P. (2011), *Solutions for a cultivated planet*, "Nature", No. 478, pp. 337-342, DOI: 10.1038/nature10452.

Francis C., Lieblein G., Gliessman S., Breland T.A., Creamer N., Harwood R., Salomonsson L., Helenius J., Rickerl D., Salvador R., Wiedenhoeft M., Simmons S., Allen P., Altieri M., Flora C., Poincelot R. (2003), *Agroecology: the Ecology of Food Systems*, "Journal of Sustainable Agriculture", Vol. 22, Issue 3, pp. 99-118.

Fuglie K.O., Kascak C.A. (2011), *Adoption and diffusion of natural-resource conserving agricultural technology*, "Applied Economic Perspectives and Policy" Vol. 23, Issue 2, pp. 386-403.

Garbach K., Milder J.C., DeClerck F.A., de Wit M.A., Driscoll L., Gemmill-Herren B. (2016), *Examining multi-functionality for crop yield and ecosystem services in five systems of agroecological intensification*, "International Journal of Agricultural Sustainability", Vol. 22, Issue 1, pp. 11-28, DOI: 10.1080/14735903.2016.1174810.

Geels F.W., Schot J. (2007), *Typology of sociotechnical transition pathways*, "Research Policy", Vol. 36, Issue 3, pp. 399-417, DOI: 10.1016/j.respol.2007.01.003.

Geertsema W., Rossing W., Landis D., Bianchi F., van Rijn P., Schaminée J., Tscharntke T., van der Werf W. (2016), *Actionable knowledge for ecological intensification of agriculture*, "Frontiers in Ecology and the Environment", Vol. 14, Issue 4, DOI: 10.1002/fee.1258.

Gibon A., Sibbald A.R., Flamant J.C., Lhoste P., Revilla R., Rubino R., Sørensen J.T. (1999), *Livestock farming systems research in Europe and its potential contribution for managing towards sustainability in livestock farming*, "Livestock Production Science", Vol. 61, Issue 2-3, pp. 121-137.

Gliessman S.R. (2007), *Agroecology: the ecology of sustainable food systems*, CRC/Taylor & Francis, New York, p. 384.

Gliessman S.R. (1990), *Quantifying the Agroecological Component of Sustainable Agriculture: A Goal* [in:] *Agroecology*, ed. S.R. Gliessman, "Ecological Studies. Analysis and Synthesis", Vol. 78, Springer, New York, DOI: 10.1007/978-1-4612-3252-0_21.

González de Molina M. (2015), *Agroecology and Politics: On the Importance of Public Policies in Europe* [in:] *Law and agroecology: A transdisciplinary dialogue*, eds. M. Monteduro, P. Buongiorno, S.Di Benedetto and A. Isoni, Springer, pp. 410-495, DOI: 10.1007/978-3-662-46617-9_20.

González de Molina M., Guzmán Casado G.I. (2017), *Agroecology and Ecological Intensification. A Discussion from a Metabolic Point of View*, "Sustainability", Vol. 9, Issue 86, pp. 1-19.

Griffon M. (2013), *Qu'est-ce que l'agriculture écologiquement intensive?* Editions Quae, Versailles, p. 227.

Hamonts K., Trivedi P., Garg A., Janitz C., Grinyer J., Holford P., Botha F.C., Anderson I.C., Singh B.K. (2018), *Field study reveals core plant microbiota and relative importance of their drivers*, "Environmental Microbiology", Vol. 20, Issue 1, pp. 124-140.

Hazell P., Wood S. (2008), *Drivers of change in global agriculture*, "Philosophical Transactions of the Royal Society B: Biological Sciences", Vol. 363, Issue 1491, pp. 495-515.

Hecht S.B. (1995), *The evolution of agroecological thought* [in:] *Agroecology: the science of sustainable agriculture*, ed. M.A. Altieri, Westview Press, Boulder, CO, pp. 1-19.

Himmelstein J., Ares A., van Houweling E. (2016), *Sustainable intensification: a multifaceted, systemic approach to international development*, "Journal Science Food Agricultural", Vol. 96, Issue 15, pp. 4833-4839, DOI: 10.1002/jsfa.7831.

Holt-Giménez E., Altieri M. (2013), *Agroecology, Food Sovereignty, and the New Green Revolution*, "Agroecology and Sustainable Food Systems", Vol. 37, Issue 1, pp. 90-102, DOI: 10.1080/10440046.2012.716388.

Horlings L.G., Marsden T.K. (2011), *Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'*, "Global Environmental Change", Vol. 21, pp. 441-452, DOI: 10.1016/j.gloenvcha.2011.01.004.

Human Technopole Foundation (2018), *Agri Food and Nutrition Genomics Center* [https://www.htechnopole.it/wp-content/uploads/2018/01/C3-afng.pdf].

Ikerd J.E. (2009), *Rethinking the First Principles of Agroecology* [in:] *Sustainable Agroecosystem Management. Integrating Ecology, Economics and Society*, eds. P.J. Bohlen and G. House, CRC, Boca Raton, pp. 41-52.

Infante-Amate J., González de Molina M. (2013), *"Sustainable de-growth" in agriculture and food: an agroecological perspective on Spain's agri-food system (year 2000)*, "Journal of Cleaner Production", Vol. 38, pp. 27-35.

Kopnina H. (2016), *The victims of unsustainability: a challenge to sustainable development goals*, "International Journal of Sustainable Development & World Ecology", Vol. 23, No. 2, pp. 113-121, DOI: 10.1080/13504509.2015.1111269.

Krasowicz S. (2009), *Możliwości rozwoju różnych systemów rolniczych w Polsce*, "Roczniki Nauk Rolniczych", seria G , T. 96, z. 4.

Lampkin N.H., Pearce B.D., Leake A.R., Creissen H., Gerrard C.L., Girling, R., Lloyd S., Padel S., Smith J., Smith L.G., Vieweger A., Wolfe M.S. (2015), *The role of agroecology in sustainable intensification. Report for the Land Use Policy Group*, Organic Research Centre, Elm Farm and Game & Wildlife Conservation Trust.

Lang T., Heasman M. (2015), *Food Wars: The Global Battle for Mounts, Minds and Markets*, Routledge, London.

Lobao L. (1990), *Locality and inequality: farm and industry structure and socioeconomic conditions*, State University of New York Press, New York.

Loos J., Abson D., Chappell M., Hanspach J., Mikulcak F., Tichit M., Fischer J. (2014), *Putting meaning back into, "sustainable intensification"*, "Frontiers in Ecology and the Environment", Vol. 12, No. 6, pp. 356-361.

Lowrance R., Stinner B.R., House G.J. (1984), *Agricultural ecosystems: unifying concepts*, Wiley, New York.

Maciejczak M. (2017), *Bioeconomy as a Complex Adaptive System of Sustainable Development*, "Journal of International Business Research and Marketing", Volume 2, Issue 2, pp. 7-10.

Maciejczak M. (2016a), *Koszty współistnienia w biogospodarce na przykładzie produkcji równoległej w gospodarstwach ekologicznych z województwa mazowieckiego*, "Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu", t. XVIII, z. 5, pp. 149-157.

Maciejczak M. (2016b), *Real-Time Delphi Survey on Competition and Competitiveness of Geographical Indications as a Negotiations Issue of The Transatlantic Trade and Investment Partnership*, "Acta Scientiarium Polonorum. Oeconomia", No. 15(1), pp. 65-74.

Maciejczak M. (2002), *Ewolucja światowego sektora nasiennego*, "Hodowla Roślin i Nasiennictwo", No. 3.

Maciejczak M., Filipiak T., Runowski H. (2017), *Perspektywy intensyfikacji rolnictwa na drodze industrialnej* [in:] *Z badań nad rolnictwem społecznie zrównoważonym [39]*, ed. J.St. Zegar, Monografie Programu Wieloletniego 2015-2019, nr 42, IERiGŻ-PIB, Warszawa.

Mahon N., Crute I., Simmons E., Islam M.M. (2017), *Sustainable intensification – "oxymoron" or "third-way"? A systematic review*, "Ecological Indicators", Vol. 74 pp. 73-97,
DOI: 10.1016/j.ecolind.2016.11.001.

Marsden T.K. (2012), *Towards a Real Sustainable Agri-food Security and Food Policy: Beyond the Ecological Fallacies?* "The Political Quarterly", Vol. 83, No. 1, pp. 139-145, DOI: 10.1111/j.1467-923X.2012.02242.x.

Martyniuk S. (2012), *Scientific and practical aspects of legumes symbiosis with root-nodule bacteria*, "Polish Journal of Agronomy", Vol. 9, pp. 17-22.

Milder J., Garbach K., DeClerck F., Driscoll L., Montenegro M. (2012), *An assessment of the multi-functionality of agroecological intensification*, Report to the Bill and Melinda Gates Foundation, Washington, DC: EcoAgriculture Partners.

Mockshell J., Kamanda J. (2018), *Beyond the agroecological and sustainable agricultural intensification debate: Is blended sustainability the way forward?*, "International Journal of Agricultural Sustainability", Vol. 16, Issue 2, pp. 127-149, DOI: 10.1080/14735903.2018.1448047.

North D.C. (1992), *Institutions, Ideology, and Economic Performance*, "Cato Journal" Vol. 11, No. 3, pp. 477-496.

O'Kane G. (2012), *What is the real cost of our food? Implications for the environment, society and public health nutrition*, "Public Health Nutrition", Vol. 15, pp. 268-276, DOI: 10.1017/S136898001100142X.

O'Leary M., Chia R. (2007), *Epistemes and Structures of Sensemaking in Organizational Life*, "Journal Management Inquiry", Vol. 16, Issue 4, pp. 392-406, DOI: 10.1177/1056492607310976.

OECD (2017), *Agenda na Rzecz Zrównoważonego Rozwoju 2030: W Kierunku Pomyślnego Wdrożenia w Polsce*, seria: "Lepsza Polityka Państwa", Warszawa.

Phelan P.L. (2009), *Ecology-based Agriculture and the Next Green Revolution: Is Modern Agriculture Exempt from the Laws of Ecology?* [in:] *Sustainable Agroecosystem Management. Integrating Ecology, Economics, and Society*, eds. P.J. Bohlen and G. House, CRC, Boca Raton, pp. 97-135.

Plumecocq G., Debril T., Duru M., Magrini M.-B., Sarthou J., Therond O. (2018), *The plurality of values in sustainable agriculture models: diverse lock-in and coevolution patterns*, "Ecology and Society", Vol. 23, Issue 1, DOI: 10.5751/ES-09881-230121.

Poczta W. (2015), *Wspólna Polityka Rolna wobec koncepcji intensyfikacji i zrównoważonego rozwoju rolnictwa*, III Kongres Nauk Rolniczych, 10 września, Warszawa [https://kongres.cdr.gov.pl/images/P4_3_Poczta.pdf].

Popkin B.M. (1993), *Nutrional patterns and transitions*, "Population and Development Review", Vol. 19, pp. 138-157.

Pretty J.N. (2008), *Agricultural sustainability: Concepts, principles and evidence*, "Philosophical Transaction of The Royal Society B: Biological Sciences", Vol. 363(1491), pp. 447-465, DOI: 10.1098/rstb.2007. 2163.

Pretty J., Benton T.G., Bharucha Z.P., Dicks L.V., Flora C.B., Godfray H.C.J., Wratten S. (2018), *Global assessment of agricultural system redesign for sustainable intensification*, "Nature Sustainability", Vol. 1, Issue 8, pp. 441-446, DOI: 10.1038/s41893-018-0114-0.

Pretty J., Bharucha Z. (2014), *Sustainable intensification in agricultural systems*, "Annals of Botany", Vol. 114, Issue 8, pp. 1571-1596, DOI: 10.1093/aob/mcu205.

Pretty J., Toulmin C., Williams S. (2011), *Sustainable intensification in African agriculture*, "International Journal of Agricultural Sustainability", Vol. 9, Issue 1, pp. 5-24, DOI: 10.3763/ijas.2010.0583.

Rockström J., Williams J., Daily G., Noble A., Wetterstrand H., DeClerck F., Shah M., Steduto P., de Fraiture Ch., Hatibu N., Unver O., Bird J., Sibanda L., Smith J. (2017), *Sustainable intensification of agriculture for human prosperity and global sustainability*, "Ambio", Vol. 46, Issue 4, DOI: 10.1007/s13280-016-0793-6.

Rosin Ch., Stock P., Campbell H. (2012), *Food Systems Failure: The Global Food Crisis and the Future of Agriculture*, Earthscan Press, London.

Rutkowski A. (1989), *Norman Ernst Borlaug. Laureat Nagrody Nobla*, "Postępy Nauk Rolniczych", Vol. 36, Issue 41, pp. 87-88.

Schenker J.L. (2017), *How Plant Microbiomes Could Disrupt Farming*, The Innovator news [https://innovator.news/how-plant-microbiomes-could-disrupt-farming-118a0f5bbc3].

Sessitsch A., Brader G., Pfaffenbichler N., Gusenbauer D., Mitter B. (2018), *The contribution of plant microbiota to economy growth*, "Microbial biotechnology", Vol. 11, Issue 5, pp. 801-805.

Staniszewski J. (2018), *Wpływ struktur wytwórczych na zrównoważoną intensyfikację produkcji rolnej w krajach Unii Europejskiej po 2004 roku*, praca doktorska, Uniwersytet Ekonomiczny w Poznaniu, Poznań.

Struik P.C., Kuyper T.W. (2017), *Sustainable intensification in agriculture: the richer shade of green. A review*, "Agronomy for Sustainable Development", Vol. 37, Issue 39, pp. 1-15, DOI: 10.1007/s13593-017-0445-7.

Struik P.C., Kuyper W., Brussaard L., Leeuwis C. (2014), *Deconstructing and unpacking scientific controversies in intensification and sustainability: why the tensions in concepts and values?* "Current Opinion in Environmental Sustainability", Vol. 8, pp. 80-88, DOI: 10.1016/j.cosust.2014.10.002.

Tellarini V., Caporali F. (2000), *An input/output methodology to evaluate farms as sustainable agroecosystems. An application of indicators to farms in Central Italy*, "Agriculture, Ecosystems & Environment", Vol. 77, Issues 1-2, pp. 111-123, DOI: 10.1016/S0167-8809(99)00097-3.

Thijs S., Sillen W., Rineau F., Weyens N., Vangronsveld J. (2016), *Towards an Enhanced Understanding of Plant-Microbiome Interactions to Improve Phytoremediation: Engineering the Metaorganism*, "Frontiers in Microbiology", Vol. 7, p. 341.

Thirtle C., Lin L., Holding J., Jenkins L., Piesse I. (2004), *Explaining the Decline in UK Agricultural Productivity Growth*, "Journal of Agricultural Economics", Vol. 55, Issue 2.

Tittonell P. (2014), *Ecological intensification of agriculture – sustainable by nature*, "Current Opinion in Environmental Sustainability", No. 8, pp. 53-61, DOI: 10.1016/j.cosust.2014.08.006.

Tittonell P., Giller K.E. (2013), *When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture*, "Field Crops Research", Vol. 143, pp. 76-90, DOI: 10.1016/j.fer.2012.10.007.

Tscharntke T., Clough Y., Wanger T.C., Jackson L., Motzke I., Perfecto I., Vandermeer J., Whitbread A. (2012), *Global food security, biodiversity conservation and the future of agricultural intensification*, "Biological Conservation", Vol. 151, Issue 1, pp. 53-59, DOI: 10.1016/j.biocon.2012.01.068.

Unold J. (2003), *Dynamika systemu informacyjnego a racjonalność adaptacyjna: teoretyczno--metodologiczne podstawy nowego ujęcia zasady racjonalności*, Prace Naukowe Akademii Ekonomicznej we Wrocławiu. Seria: Monografie i Opracowania, nr 977.

Uphoff N. (2014), *Systems thinking on intensification and sustainability: systems boundaries, processes and dimensions*, "Current Opinion in Environmental Sustainability", Vol. 8, pp. 89-100, DOI: 10.1016/j.cosust.2014.10.010.

Valenzuela H. (2016), *Agroecology: A Global Paradigm to Challenge Mainstream Industrial Agriculture*, "Horticulturae", Vol. 2, pp. 2-11.

Vanlauwe B., Blomme G., van Asten P. (2013), *Agro-ecological intensification of farming systems in the East and Central African highlands* [in:] *Agro-ecological intensification of agricultural systems in the African Highlands*, eds. B. Vanlauwe, P. van Asten and G. Blomme, Routledge, London and New York, pp. 1-17.

Warner K.D. (2007), *Agroecology in Action: Extending Alternative Agriculture through Social Networks (Food, Health and the Environment)*, MIT Press, p. 273.

Westra J., Boody G. (2009), *Challenges and Benefits of Developing Multifunctional Agroecosystems* [in:] *Sustainable Agroecosystem Management. Integrating Ecology, Economics and Society*, eds. P.J. Bohlen and G. House, CRC, Boca Raton, pp. 213-233.

Wezel A., Bellon S., Doré T., Francis C., Vallod D., David C. (2009), *Agroecology as a science, a movement and a practice, A review*, "Agronomy for Sustainable Development", Vol. 29, Issue 4, p. 503, DOI: 10.1051/agro/2009004.

Wezel A., Soboksa G., McClelland S., Delespesse F., Boissau A. (2015), *The blurred boundaries of ecological, sustainable, and agroecological intensification: a review*, "Agronomy for Sustainable Development", Vol. 35, Issue 4, pp. 1283-1295, DOI: 10.1007/s13593-015-0333-y.

Wrzaszcz W. (2017), *Sustainable Intensification vs. Farms' Economic Outcomes – the case of Poland*, "European Journal of Sustainable Development", Vol. 6, No. 3, pp. 347-359, DOI: 10.14207//ejsd.2017.v6n3p347.

Zarraonaindia I., Owens S.M., Weisenhorn P., West K., Hampton-Marcell J., Lax S., Bokulich N.A., Mills D.A., Martin G., Taghavi S., van der Lelie D., Gilbert J.A. (2015), *The Soil Microbiome Influences Grapevine-Associated Microbiota*, "mBio", Vol. 6, Issue 2, DOI: 10.1128/mBio.02527-14.

Zegar J.St. (2017), *Cele społeczne w polityce zrównoważonego rozwoju rolnictwa i obszarów wiejskich* [in:] *Z badań nad rolnictwem społecznie zrównoważonym [39]*, ed. J.St. Zegar, Monografie Programu Wieloletniego 2015-2019, nr 47, IERiGŻ-PIB, Warszawa.

Zegar J.St. (2012), *Współczesne wyzwania rolnictwa*, PWN, Warszawa.

CHAPTER III: AGRICULTURE PRODUCTION POTENTIAL AND FARMS' ENVIRONMENTAL SUSTAINABILITY – REGIONAL CONVERGENCE OR DIVERGENCE?

Adamowicz M. (2016), *Biogospodarka jako inteligentna specjalizacja w strategiach rozwoju polskich regionów*, "Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnych i Agrobiznesu", tom VIII, z. 1, pp. 9-16.

Adamowicz M., Szepeluk A. (2018), *Regional convergence of labour productivity in rural sectors in the context of funds obtained for agriculture from the European Union*, "Problems of Agricultural Economics", 3(356), pp. 3-31, DOI: 10.30858/zer/94473.

Bocian M., Cholewa I., Tarasiuk R. (2017), *Współczynniki Standardowej Produkcji „2013" dla celów Wspólnotowej Typologii Gospodarstw Rolnych*, IERiGŻ-PIB, Zakład Rachunkowości Rolnej, Warszawa.

Feledyn-Szewczyk B. (2015), *Bioróżnorodność w koncepcji świadczeń ekosystemowych i metody jej wyceny*, IUNG-PIB, Puławy.

Feledyn-Szewczyk B. (2014), *Wpływ systemów produkcji rolnej na bioróżnorodność i świadczenia ekosystemowe* [in:] *Z badań nad rolnictwem społecznie zrównoważonym [24]*, ed. J.St. Zegar, Program Wieloletni 2011-2014, No. 109, IERiGŻ-PIB, Warszawa, pp. 11-30.

Floriańczyk Z., Osuch D., Płonka R., (2018), *2016 Standard Results of Polish FADN agricultural holdings*, IAFE-NRI, Agricultural Accountancy Department, Warsaw.

Goraj L., Bocian M., Cholewa I., Nachtman G., Tarasiuk R. (2012), *Współczynniki Standardowej Produkcji „2007" dla celów Wspólnotowej Typologii Gospodarstw Rolnych*, IERiGŻ--PIB, Zakład Rachunkowości Rolnej, Warszawa.

GUS (2013), *Zrównoważenie polskiego rolnictwa*, ed. J.St. Zegar, Powszechny Spis Rolny 2010, Warszawa.

Harasim A. (2014), *Przewodnik do oceny zrównoważenia rolnictwa na różnych poziomach zarządzania*, IUNG-PIB, Puławy.

Henisz-Matuszczak A. (2007), *Dualny rozwój rolnictwa i obszarów wiejskich* [in:] *Uniwersalia polityki rolnej w gospodarce rynkowej, ujęcie makro i mikroekonomiczne*, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań, pp. 99-120.

http://stat.gov.pl/en/.

Karwat-Woźniak B. (2015), *The rationalization of employment in Polish agriculture* [in:] *Changes and perspectives in the rural areas and in the agriculture of Bulgaria*, *Poland and other EU Member States*, eds. D. Nikolov, A. Wrzochalska, N. Bencheva and P. Yovchevska, Avangard Prima, Sofia, pp. 165-178.

Kopiński J. (2017), *Metoda określania sald bilansów NPK oraz zakresu ich bezpieczeństwa dla środowiska przyrodniczego*, IUNG-PIB, Puławy.

Kopiński J. (2006), *Bilans składników nawozowych w gospodarstwach rolnych jako kryterium zrównoważonego gospodarowania* [in:] *Z badań nad rolnictwem społecznie zrównoważonym [2]*, ed. J.St. Zegar, Program Wieloletni 2005-2009, No. 30, IERiGŻ-PIB, Warszawa, pp. 83-91.

Krasowicz S. (2005), *Cechy rolnictwa zrównoważonego* [in:] *Koncepcja badań nad rolnictwem społecznie zrównoważonym*, ed. J.St. Zegar, Program Wieloletni 2005-2009, No. 11, IERiGŻ-PIB, Warszawa, p. 25.

Kuś J., Krasowicz S., Kopiński J. (2008), *Ocena możliwości zrównoważonego rozwoju gospodarstw bezinwentarzowych* [in:] *Z badań nad rolnictwem społecznie zrównoważonym [5]*, ed. J.St. Zegar, Program Wieloletni 2005-2009, No. 87, IERiGŻ-PIB, Warszawa, pp.11-38.

Loon G.W. van, Patil S.G., Hugar L.B. (2005), *Agricultural Sustainability. Strategies for Assessment*, SAGE Publications, New Delhi/Thousand Oaks/London.

Malaga K., Kliber P. (2007), *Konwergencja a nierówności regionalne w Polsce w świetle neoklasycznych modeli wzrostu*, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań.

Manteuffel R. (1981), *Ekonomika i organizacja gospodarstwa rolniczego*, PWRiL, Warszawa.

Ministry of Agriculture and Rural Development (2018), Wsparcie Rolnictwa [http://www.minrol.gov.pl/Wsparcie-rolnictwa, access on: 20.08.2018].

Skarżyńska A. (2017), *Produkcja wołowiny w Polsce oraz czynniki determinujące jej opłacalność*, "Roczniki Naukowe Ekonomii Rolnictwa i Obszarów Wiejskich", tom 104, zeszyt 4, pp. 112-124, DOI: 10.22630/RNR.2017.104.4.36.

Smędzik-Ambroży K. (2015), *Konwergencja czy dywergencja rolnictwa w Polsce w latach 2004-2011* [in:] *Problemy rozwoju rolnictwa i gospodarki żywnościowej w pierwszej dekadzie członkostwa Polski w Unii Europejskiej*, eds. A. Czyżewski and B. Klepacki, IX Kongres Ekonomistów Polskich, PTE, pp. 110-129.

Strategia odbudowy i rozwoju produkcji trzody chlewnej w Polsce po roku 2030 mająca na celu poprawę funkcjonowania sektora produkcji wieprzowiny (2013), eds. T. Blicharski and A. Hammermeister, Polski Związek Hodowców i Producentów Trzody Chlewnej "POLSUS", Warszawa.

Trajer M., Krzyżanowska K. (2014), *Tendencje zmian na rynku mleka i możliwości współdziałania rolników w grupach producentów*, "Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu", tom XVI, z. 4, pp. 328-333.

Trojak M., Tokarski T. (2013), *Statystyczna analiza przestrzennego zróżnicowania rozwoju ekonomicznego i społecznego Polski*, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków.

WCED (1987), *Our Common Future*, Oxford University Press.

Woś A., Zegar J.St. (2002), *Rolnictwo społecznie zrównoważone*, IERiGŻ, Warszawa.

Wrzaszcz W. (2018), *Changes in Farms' Economic Sustainability: The Picture of Polish Farms in the Last Decade*, "European Journal of Sustainable Development (2018)", Vol. 7, No. 4, pp. 179-190, DOI: 10.14207/ejsd.2018.v7n4p179. .

Wrzaszcz W. (2017), *Wyniki produkcyjno-ekonomiczne gospodarstw rolnych oddziałujących w różnym zakresie na środowisko przyrodnicze*, "Zagadnienia Ekonomiki Rolnej", 2(351), pp. 3-31, DOI: 10.5604/00441600.1239730.

Wrzaszcz W. (2014), *Sustainability of Agricultural Holdings in Poland*, Studia i Monografie, No. 161, IERiGŻ-PIB, Warszawa.

Wrzaszcz W. (2010), *Bilans glebowej substancji organicznej w gospodarstwach indywidualnych objętych rachunkowością rolną FADN* [in:] *Oddziaływanie rolnictwa na środowisko przyrodnicze w warunkach zmian klimatu*, ed. A. Harasim, Studia i Raporty IUNG-PIB, Program Wieloletni 2005-2010, z. 19, IUNG-PIB, Puławy, pp. 69-89.

Wrzaszcz W. (2009), *Z badań nad rolnictwem społecznie zrównoważonym [7]. Bilans nawozowy oraz bilans substancji organicznej w indywidualnych gospodarstwach rolnych*, Program Wieloletni 2005-2009, No. 129, IERiGŻ-PIB, Warszawa 2009.

Wrzaszcz W., Zegar J.St. (2016), *Challenges for Sustainable Development of Agricultural Holdings*, “Economic and Environmental Studies”, Vol. 16, Issue 3(39), pp. 377-402.

Zegar J.St. (2012), *Współczesne wyzwania rolnictwa*, PWN, Warszawa.

Zegar J.St. (2010), *Ekonomika rolnictwa versus ekonomia agrarna* [in:] *Wieś i rolnictwo w procesie zmian. Rolnictwo w nowym otoczeniu rynkowym i instytucjonalnym*, eds. S. Sokołowska and A. Bisaga, Opole, pp. 13-24.

Zegar J.St. (2005), *Koncepcja badań nad rolnictwem społecznie zrównoważonym* [in:] *Koncepcja badań nad rolnictwem społecznie zrównoważonym*, Program Wieloletni 2005-2009, No. 11, IERiGŻ-PIB, Warszawa, pp. 9-22.

Zegar J.St., Wrzaszcz W. (2017), *The Holism Principle in Agriculture Sustainable Development*, “Economic and Environmental Studies”, Vol. 17, Issue 4(44), pp. 1051-1069.

Zeliaś A. (2000), *Metody statystyczne*, PWE, Warszawa.

CHAPTER IV: SUSTAINABILITY OF FAMILY FARMS BY PRODUCTION AND ECONOMIC TYPE IN 2005 AND 2016

Béliérs J.F., Bonnal P., Bose P.M., Marzin J., Sourisseau J.M. (2015), *Family Farming around the World*, ASAOIR 28, Cirad.

FAO (2014), *The State of food and agriculture: Innovation of family farms*, Rome.

Graeub B.E., Chappell J.M., Wittman H., Ledermann S., Benzer K.R., Gemmill-Herren B. (2016), *The State of Family Farms in the World*, World Development, Vol. 87, pp. 1-15 [http://dx.doi.org/10.1016/j.worlddev.2015.05.12].

GUS (2017a), *Charakterystyka gospodarstw rolnych w 2016 r.*, Warszawa.

GUS (2017b), *Rocznik Statystyczny Rolnictwa*, Warszawa.

GUS (2013), *Zrównoważenie polskiego rolnictwa*, ed. J.St. Zegar, Powszechny Spis Rolny 2010, Warszawa.

GUS (2006a), *Charakterystyka gospodarstw rolnych w 2005 r.*, Warszawa.

GUS (2006b), *Rocznik Statystyczny Rolnictwa i Obszarów Wiejskich*, Warszawa.

Toczyński T., Wrzaszcz W., Zegar J.St. (2009), *Z badań nad rolnictwem społecznie zrównoważonym [8]. Zrównoważenie polskiego rolnictwa w świetle danych statystyki publicznej*, Program Wieloletni 2005-2009, nr 161, IERiGŻ-PIB, Warszawa.

Ustawa z dnia 16 listopada 2016 r. o zmianie niektórych ustaw w celu ułatwienia sprzedaży żywności przez rolników [Dz. U., 2016, poz. 1961 z póź. zm.].

Wrzaszcz W. (2017), *The CAP Greening Effects – The Polish Experience*, Proceedings of the 8th International Scientific Conference Rural Development, DOI: 10.15544/RD.2017.212.

Wrzaszcz W. (2012), *Poziom zrównoważenia indywidualnych gospodarstw rolnych na podstawie danych FADN*, Studia i Monografie, nr 155, IERiGŻ-PIB, Warszawa.

Zegar J.St. (2018), *Kwestia agrarna w Polsce*, IERiGŻ-PIB, Warszawa.

Zegar J.St., Wilk W. (2007), *Zrównoważenie indywidualnych gospodarstw rolnych w świetle wybranych kryteriów* [in:] *Z badań nad rolnictwem społecznie zrównoważonym [4]*, Program Wieloletni 2005-2009, nr 59, IERiGŻ-PIB, Warszawa, pp. 2-19.

COPY FREE

Print run: 250 copies, 8.7 publisher`s sheets
Printing and binding: ZAPOL Sobczyk Spółka Jawna