The Implications of Intensified, Scaled and Concentrated Agricultural Production for the Climate and Environment

A Summary

Krajowa Sieć Obszarów Wiejskich

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This publication summarises the multi-author monograph entitled *The Implications of Intensified, Scaled and Concentrated Agricultural Production for the Climate and Environment*, which is the outcome of a seminar organised by the Foundation for the Development of Polish Agriculture (FDPA) in the village of Koprzywnica on 26–27 September 2022 as part of the project *The European Green Deal – Opportunities and Challenges for Polish Agriculture*. The monograph has six chapters that are extended versions of the papers presented at the seminar, plus two more: a summary of the seminar's discussions and the case study of an enterprise visited during the seminar, entitled *Preparing a large agri-food enterprise to implement the guidelines of the European Green Deal – the case of Goodvalley*.

The monograph looks at two major issues: (1) Whether the European Green Deal (EGD) refutes sustainable agricultural development based on intensive production methods and high-concentration agricultural production, and (2) Whether large agricultural holdings and factory farms are able to meet the requirements of environmental protection, prevent climate change and produce foodstuffs in high-quality systems. The authors of the monograph tackle these questions, taking into account the specific national context of global changes that have reverberated strongly in the national economy in the recent years, including in the agri-food sector. There can be little doubt that the world – or at least its well-developed and industrialised part – has agreed to what we in Europe term 'The Green Deal', and that its postulates will be components of sustainable development both in Europe and globally.

Therefore, the authors believe that this monograph represents a valuable contribution to the domestic and European debate on the model of European (and Polish) agriculture in the EGD era, so that it can firmly follow the path of sustainable development.

The first chapter of the monograph is entitled *The implementation of the European Green Deal and the Farm to Fork Strategy as part of the national agricultural policy and the Strategic Plan for the Common Agricultural Policy (CAP)*. The European Green Deal is a new strategy for growth that aims to transform the EU into a fair and prosperous society living in a modern, resource-efficient and competitive economy, which by 2050 will have achieved net-zero emission of greenhouse gases and in which economic growth will be separate from the use of natural resources.

The European Commission services proposed a set of changes to EU policies the range of which affects all economic sectors, including agriculture. The European Green Deal is founded on the Farm to Fork Strategy, the assumptions of which are based on the development of sustainable food systems. The transition towards a sustainable food system is expected to bring environmental, health, social and economic gains.

During the work on the CAP Strategic Plan, the European Commission services proposed recommendations to aid the programming process through identification of the key areas characterising the individual Member States.

A Summary

With regard to the target: ***foster a smart, resilient and diversified agricultural sector capable of ensuring food security***, these recommendations included:

- improving farm profitability, providing better-addressed income support, reducing the income gap between farms (mostly in favour of smaller farms), redistributive income support;
- redressing the balance of power in the food supply chain, improving the organisation of farmers and stimulating the consolidation and recognition of different types of organisations and producers' cooperatives, the support systems need to encourage farmers to develop and participate in short supply chains and to generate products with high added value.

With regard to the target: ***environmental protection and climate***, the recommendations focused on:

- reducing net emissions from agriculture through appropriate fertilisation, soil management, and management of emissions from enteric fermentation in animal nutrition;
- maintaining and establishing high-diversity landscape features and increasing the area of organic crops;
- reducing water scarcity: water retention in the soil; longer and more varied crop rotation; drought-resistant crops and species.

In relation to the target: ***strengthen the socio-economic fabric of rural areas and resolve social problems***, the EC services focused on:

- promoting employment, growth, social inclusion and local development, encouraging young people to become farmers, ensuring accessibility of basic services, developing entrepreneurship and bio-economy in rural areas; complementarity between EU and national funding;
- reducing the use of antimicrobial agents, improving animal welfare and optimising the use of pesticides.

The target involving ***knowledge sharing, innovation and digitalisation in agriculture and rural areas*** needs to focus, in particular, on ensuring access to broadband Internet and investments to develop a system of knowledge and innovation in agriculture as well as continued integration between information, knowledge, consultancy, innovation and digital skills.

The final version of the CAP Strategic Plan incorporated many solutions which followed these recommendations.

The target: ***reduce nutrient losses at EU level by 50% without soil fertility loss*** will be addressed by the **eco-schemes**: carbon farming and nutrient management; crop production using the integrated crop production method; organic farming; farm investments in renewable energy sources and improving energy efficiency; creation of mid-field forestation; investments promoting environmental and climate protection; developing services for agriculture and forestry (*financial instrument*); supporting model farms.

Outside of the Plan, complementary activities will be pursued, such as: (i) activities aimed at reducing pollution with nitrates from agricultural sources and preventing further pollution, (ii) set of recommendations concerning best farming practices for voluntary application, (iii) soil environmental restoration programme using liming, or (iv) development of agricultural biogas plants.

Achieving at least 25% of the EU's agricultural land under organic farming. The CAP Strategic Plan envisages providing comprehensive support for the organic farming sector and the organic food market, including a whole gamut of actions using both the financial resources of the CAP Strategic Plan and a range of solutions outside the Plan. These measures aim to secure the development of individual actors and stages of the organic food chain 'from field to fork'.

Reducing by 50% the overall use and risk of chemical pesticides and reducing by 50% the use of more hazardous pesticides. Reducing the use of pesticides is planned through two types of actions: (i) national legislation concerning plant protection products (PPP), (ii) interventions of the CAP Strategic Plan to promote a sustainable use of PPP and reduce risks: organic farming and the eco-scheme: biological crop protection.

Reducing the sales of antimicrobials for farmed animals and in aquaculture by 50% by 2030. A number of actions have been designed, mainly outside the CAP Strategic Plan, with the aim of reducing the use of these agents. This will ensure that the reduction of antibiotic use in livestock production follows the 'as little as possible, but as much as necessary' principle.

The CAP Strategic Plan is a major tool in the implementation of the European Green Deal, including the Farm to Fork Strategy. To supplement it, activities stemming from national legislation, consumer and business behaviours are needed.

The European Green Deal poses a daunting challenge for all European economies, including that of Poland. The rollout of this strategy is ever more important considering the ongoing war in Ukraine, high inflation, the availability of alternative technologies and the timeframe set for these solutions to be implemented. Attaining the EGD goals needs to draw on the knowledge of all the links making up the agri-food sector. For this reason, it is necessary to ensure effective knowledge transfer and foster innovation in agriculture, including the use of digital technologies.

The next chapter, entitled *Increased scale, intensity and concentration of animal production – in Europe and worldwide*, shows that the European Green Deal (EC, 2019) alongside the Farm to Fork Strategy (COM(2020) 381 final) map out new directions of development not only for European animal production, but also farming in general. European economy can no longer rely on the linear model of growth, and the constantly increasing resource consumption and waste generation. Efforts should be made to promote a new model – circular economy. So-called 'Green Architecture' is an example of such an approach in the forthcoming CAP programming period, with a 25% share of organic farming, a 50% reduction in the use of antibiotics and herbicides, a 20% decrease in the losses caused by nitrogen mineral fertilisation transition to zero-emission management; improving animal welfare; introducing carbon farms and bioeconomy.

Environmental protection and climate regulations, if suitably designed, could encourage innovation that would – in whole or in part – compensate for the costs of these regulations being observed. In other words, pollutant emissions and production costs would fall simultaneously, a perfect win-win situation. The adopted goals may be attained mostly by changes made in the organisation of production, such as more precise methods and technologies, but also legal norms and voluntary modification of approach by all stakeholders, ranging from agricultural input suppliers to the banking sector.

A Summary

Intensive animal, or factory farming, can be defined as an activity aimed at maximising profits through high volume production while minimising its costs, particularly unit costs. In this case, the resultant market advantage comes from capital expenditure and the application of solutions created by scientific progress, such as production technologies and techniques, genetics, health, nutrition and farm management, all leading to increased animal productivity. Globalisation and genetic progress can also be counted as additional characteristics of factory farming. Without the former, understood as supply chains (e.g. South American soy) and distribution (e.g. Asian countries), the development of industrial farms would not be possible.

In order to satisfy the growing demand for meat and other animal products, animal breeding has seen a significant increase worldwide in the last decade. In 2020, global meat production totalled ca 337.2 million tons. The number of broiler chicken alone totalled ca 33.1 billion, a roughly 130% increase compared to 2000. The World Bank forecasts estimate that by 2030 the global food demand will have increased by 50%, and meat demand by 85%. According to the World Bank's estimates, in 2025 one hectare of agricultural land will have to feed five people, compared to a mere two in 1960. At present, 72.2% of all animals being bred in the EU are kept in intensive farming conditions. In Europe, large pig farms (with over 2,000 livestock) represent only 0.3% of all pig farms in the EU, but they account for 16% of the EU's pig population. Similarly, large laying hen farms (with over 40,000 population) represent a mere 0.1% of the total number of such farms, but account for 59% of the hen population in the EU.

In Poland, the changes currently taking place also point to the continued specialisation of farms towards intensive fattening of purchased pigs (the open cycle), mostly from abroad (Denmark). One consequence of this process is a considerable reduction of the sow basic herd (by 42.8%). In that regard, 2021 saw a leap in the process. The overall fall in the pig population in the decade concerned reached as much as 26.8%. This was mainly due to the low profitability of fattening, in addition to outbreaks of the African swine fever (ASF) and the accompanying problems with the sale or culling of infected animals. In 2020, only ca 85,000 agricultural holdings bred pigs, compared to 389,000 in 2010 and 70,000 in 2021. Since 2001, herd size has continually increased from 11–50 animals to as many as 200 or more. Today, over 40% of the total pig population is bred in herds of 100 or more animals.

In 2013, the CAP was reviewed and modified yet again; revision built on previous structures that focused on offering support to the producer and not the product and labour, and on some aspects of sustainable development such as the use of resources. These funds first and foremost targeted small farms and young farmers, and addressed the issues of environmental protection and climate. In addition to direct payments in the 2023–2027 programming period, Member States will also receive funding for EGD implementation as part of the of the second pillar of the CAP. Among the most relevant to animal husbandry, there are:

- support to organic farming
- support to farmers in areas with natural constraints
- support to farmers pursing climate-friendly farming practices with higher environmental benefits, i.e., agri-environmental measures and eco-schemes
- support for investments aimed at improving farm competitiveness and environmental performance
- support to food processing and food production.

One of the ways in which the EGD goals can be met is precision farming. Precision Livestock Farming (PLF) and Precision Agriculture (PA), are constituent parts of Smart Agriculture (SA). The notion of precision

livestock farming refers to a management approach based on real-time feedback and aimed at eliminating variability that can disturb the effectiveness of the process itself.

The transition of livestock farming to the stage of precision production is encouraged by developments in information and digital technologies, including microprocessor-based chemical, optical and biophysical sensors or biomarkers. However, the flow and analysis of the accumulated information, and then of feedback instructions, was not possible until the onset of information and communication technologies (ICT). In operating tractors using GPS, accuracy alone can help reduce the volume of fertilisers or plant production products by 15%. The use of milking robots eliminates a milker's work by 100%, as is the case with self-propelled fodder mixers. Naturally, these are not cheap, but they can reduce operational expenses in the cost structure by as much as 25%.

Today's consumer prefers quality food, which requires appropriate production methods. Their description and even videos of the farm are made available to consumers, typically by loading a QR code through their smartphones. Eurobarometer surveys (2019) found that nutritional value and taste alone as the leading advertising concept are not sufficient for European consumers. More than 91% of the respondents considered such attributes to be no more than a standard expectation. What most determines consumers' judgment of food quality now are the production methods. These may include organic farming, animal welfare, low emissions or the use of antibiotics in livestock husbandry.

Antimicrobial resistance associated with excessive and improper use of such agents in animal treatment annually leads to ca 33,000 deaths in EU/EEA21 and involves substantial healthcare costs. It is estimated that, given the increasing meat consumption worldwide, the total use of antibiotics in livestock rose from 131,000 tons in 2013 to 160,000 tons in 2020. This number is expected to grow to a little over 200,000 tons in 2030.

The EU's efforts in the field of animal health made in recent years, which included, among others, implementing best practices to improve animal health and welfare and minimise the incidence of diseases, resulted in a 43.2 % fall in total sales of veterinary antimicrobial agents in 25 countries across Europe in 2011–2020. Areas affected by the operation of factory farms are characterised by worsened air quality, attributed mainly to dust, gas and endotoxin (the main components of Gram- cell walls) emissions.

In addition, pathogenic viruses and bacteria and antimicrobial-resistant bacteria (AMR) can be found in the air around such farms. Recent research findings show that livestock farming has a significant share in anthropogenic dust emissions ($PM_{2.5}$), composed mainly of secondary inorganic aerosols, including ammonium sulphate and ammonium nitrate.

While so-called intestinal fermentation in cattle is the primary source of methane emissions in agriculture, nitrogen oxide emissions are mainly due to both nitrogen fertilisation and manure management (buildings, storage). Therefore, such emission sources need to be mitigated if a low-emission product is to be launched onto the food market. In turn, soil carbon sequestration will be subject to a separate certification process. So-called carbon farms, operating either under the CAP Strategic Plan eco-schemes (2023–2027) or private systems, will document the accumulation of organic matter by their farming practices or cultivation systems. Such measures include agro-forestry systems, creation of mid-field forestation, intermediate crops, reduced tillage, ploughing in of harvest residues and extensive use of permanent grassland, etc.

A Summary

The entire system will, naturally, be certified, and the accumulated carbon credits will be sold on the voluntary carbon offset market.

The CAP had very a good reason to include in its remit not only agriculture, but also rural areas and a broad range of public and ecosystem services that can be offered by the farming sector to the society at large. Seen in this context, intensive agricultural production is not likely to disappear from the market as the primary provider of widely available, inexpensive and safe food. However, it will need to demonstrate its contribution to the implementation of the strategy designed for the whole EU economy, by such measures as making new outlays needed to improve production quality and incorporating into its standards its impact on animals, biodiversity, environment and climate.

The next chapter, entitled *Increased scale, intensity and concentration of crop production – in Europe and worldwide*, posits that since the onset of the Industrial Revolution 1.0 the overriding goal of crop production was to maximise it, on account of the growing demographic pressure that gradually boosted the demand for food. In 1820, the world's global population totalled ca 1 billion; it doubled in 110 years, to reach 3 billion in 1960. According to most recent UN forecasts, in 2050 the world's population will be 9.7 billion – a nearly tenfold increase in comparison to 1820.

How to ensure food for the ever-increasing global population was an issue that attracted attention as early as the 18th century. In that regard, Thomas Malthus made a name for himself; English professor of political economy, in 1798 he published his overpopulation theory. The Malthusian theory held that the Earth's population increased exponentially, and food production arithmetically, and therefore, poverty and famine would become inevitable as early as mid-19th century. Nonetheless, the development of ammonia synthesis by German chemists Fritz Haber and Carl Bosch, and the start of mass-scale production of mineral fertilisers in 1914, made it possible to maintain the rate of growth in food production at the level not lower than the increase in the world's population.

Nowadays, however, in view of the forecasted continued growth of the Earth's population, food production needs to rise by as much as 60–70% by 2050. Given the limited possibilities for increasing the areas under cultivation, this will be 80% percent based on intensifying production on already cultivated farmland.

The intensification of crop production is typically assessed by the use of mineral fertilisers and PPP, i.e., yield-increasing industrial inputs. In turn, the specialisation of farms and the associated increase in their scale production are among the major factors in increasing yields, ensuring progress in crop production and development of the agricultural sector. In the majority of North and South America, Western and Central Europe, and Asia, N application is at a level of ca 50 to 200 kg/ha, whereas lower amounts are commonly used in Russia, Australia and most African countries.

Notably, despite a lower level of agriculture intensity in Poland, the use of fertilisers is higher or similar to other EU countries, given its lower crop productivity due to less favourable soil and climate conditions.

Conversely, when it comes to the use of plant PPP, their consumption worldwide is 1.81 kg/ha, compared to 1.6 kg/ha in Europe. Relatively high PPP use is found mainly in the agriculture of China, both Americas and the Mediterranean countries with their prevalent horticultural production.

Unfortunately, the intensification of crop production and the increasingly higher application of fertilisers and plant production products have a negative impact on all environmental elements. Excessive quantities of nutrients from fertilisers, among others, lead to the formation of particulate matter and smog, global warming, depletion of the ozone layer, soil acidification and salinisation, increased trophicity of aquatic and terrestrial ecosystems or reduced biodiversity. In the natural environment, PPP will also be transformed and transported across ecosystems. In their primary form and/or as their derived metabolites, they can penetrate into soil, water, the atmosphere, as well as into human food and animal feed. This means that they pose a threat to living organisms.

It has been demonstrated that attaining the goals of EU policies aimed at mitigating pollution while maintaining or increasing the level of crop production, will pose a serious challenge, one that will call for amalgamating several pro-environment strategies. In this, managing farm size can significantly affect the environmental efficiency of crop production. Some research findings indicate that a 1% increase in farm size will reduce the consumption of PPP by 1.8% and fertilisers by 0.3%. Soils in large-scale farms have a 6–9% higher organic carbon content, a 48% lower carbon dioxide emission and a lower carbon footprint (by 8%–28%). Their potential with regard to global warming, eutrophication, acidification, as well as ecotoxicity, is 1.6–12.7% lower than in small-scale farms.

Due to the economies of scale, large-scale farms provide the ideal platform for implementing state-of-the-art farming best practice. Some researchers believe that small-scale farms can act as a barrier to sustainable development, particularly in countries where they are the dominant form in the agrarian structure. At the same time, it should be borne in mind that crop production in large-scale farms can adversely affect the environment, for example, by generating biodiversity loss or soil erosion in hilly areas.

The European Green Deal (EGD) and its strategies come as a response to the challenges facing Europe and the world regarding food, environmental and climate security. Importantly, nearly all EGD components are directly or indirectly linked to crop production, while the transition to a sustainable food system is expected to generate benefits for the environment, public health and society at large alongside fairer economic returns.

Similarly, we should not overlook the threats that may be associated with the EGD. According to analysts from the US Department of Agriculture, rolling out the Green Deal in the European Union will lead to a fall in its oilseed production by 61%, wheat by 49%, and other crops by 44%, which in turn is expected to reduce market availability of agricultural commodities and result in their higher prices.

An analysis conducted by a consortium of experts from three academic centres – Institute of Rural and Agricultural Development of the Polish Academy of Sciences in Warsaw, Institute of Soil Science and Plant Cultivation – National Research Institute in Puławy and Faculty of Economics of Poznań University of Life Sciences, entitled *The impact of the European Green Deal on Polish agriculture*, suggests that the introduction of the EGD will mean a reduction in crop production by 13% and a loss of income from the analysed crops by ca 11%. The above notwithstanding, the fulfilment of the EGD objectives ought to have a positive effect on the condition of the natural environment in Poland. Still, it is as yet uncertain whether all the ambitious environmental objectives laid down in the EGD are likely to be fulfilled over a relatively short period of time. The authors of the report are of the opinion that it will first and foremost depend on

the adopted mode and pace of implementation, as well as solutions and instruments envisaged in Poland's agricultural policy.

Some authors posit that the key to success in implementing pro-environmental measures lies in a better understanding and acknowledging socio-economic barriers in agriculture. In the Polish context, it should be borne in mind that small farms can pose a barrier to sustainable intensification of crop production, and the application of such pro-environmental practices needs to vary from region to region.

The quality of Polish soil is among the poorest in Europe: the average production potential of an average hectare of soil in Poland corresponds to that of 0.6 ha arable land in EU countries. Therefore, rational soil management and gradual improvement of its properties are of paramount importance. This includes optimisation of the environment where nitrogen is transformed, first and foremost by adjusting pH levels and soil abundance in macro- and microelements based on regular soil analyses.

The authors of the next chapter, entitled *The impact of agriculture on the quality of nature resources: The status quo and its determinants*, argue that agriculture and nature resources represent a naturally operating system of communicating vessels, in which agricultural production depends on such resources as water, soil, air or biota. At the same time, intensive use of farmland can further exacerbate environmental pollution and accelerate biodiversity loss.

Agriculture – among other things – is a considerable source of excess biogenic substances (notably nitrogen and phosphorus) in the environment. This is due to the overuse of fertilisers and the fact that not all agricultural nutrients are effectively taken up by plants – unabsorbed fertilisers then pollute soil, water and air. In this way, they adversely affect the preservation of biodiversity, e.g. in surface waters and water-dependent ecosystems (wetlands). In view of the negative effects of overfertilisation, in the Farm to Fork Strategy the European Commission called for the introduction of measures aimed at reducing losses in nutrient uptake by at least 50% while ensuring that soil fertility will not deteriorate.

These measures follow up and expand on the earlier activities pursued by the European Commission, which were aimed at containing the negative impact of agriculture on waters, e.g. *Council Directive of 12 December 1991 (91/676/EEC) concerning the protection of waters against pollution caused by nitrates from agricultural sources* (JL 91.375.1, also known as the Nitrates Directive). The report on the implementation of Directive 91/676/EEC in 2016–2020 outlines the impact of agriculture on nitrate concentration in surface waters (rivers and lakes) and groundwater. The annual nitrate concentration did not exceed 25 mg NO_3/l (threshold value for waters at risk) at 87.2% points measuring the chemical status of groundwater; at 99.8% monitoring points in rivers and 99.8% in lakes. Values of 50 mg NO_3/l (threshold value for soiled waters) or higher were found at 4.66% points monitoring groundwater, at 0.03% points in rivers, and in none of the monitored lakes.

Increased nitrate and phosphate concentrations facilitate the enrichment of surface waters, i.e., their eutrophication, which accelerates secondary water pollution in the form of algal blooms or cyanobacteria. The Nitrates Directive also highlights the threat of eutrophication. As part of the *Report on the implementation of Directive 91/676/EEC (nitrates) in 2016–2020*, the trophicity of surface water was evaluated at 3,615 out of 4,299 all monitoring points. In the period at hand, eutrophication was ascertained at 50% analysed

points on rivers, and another 19% points found them likely to become eutrophic. In the case of monitored and classified lakes, 77% were found as eutrophic and 23% as being at risk of eutrophication.

The locally generated losses of biogenic substances from agricultural land impact on the entire catchment area, and thus contribute to polluting first rivers and reservoirs, and subsequently marine waters. The load discharged into the Baltic Sea is still too high to ensure a desirable ecological state of the Baltic Sea in terms of eutrophication. It should be emphasised that in the catchment areas of both the Vistula River and the Oder River, 61% of the total nitrogen load originates from agriculture; for phosphorus, agriculture accounts for 51% of the total phosphorus load discharged via the Vistula River, and 42% via the Oder River.

The required reduction of pollutant emissions from agriculture ought to be effected not by limiting agricultural production but by improving farming practices, as well as better understanding and broader use of ecological processes at the boundaries of waters and soils in the areas used for agricultural production.

The needs in the sphere of reducing pollution, improving biodiversity and adaptation to climate change in agricultural areas can be addressed by nature-based solutions (NBS). NBSs are currently being developed in the European Union, not only by researchers, but have also been incorporated into EU policies, as evidenced by the provisions of the EU's Biodiversity Strategy (EC 2020b).

For water management in rural areas to be effective, a catchment-based approach needs to be applied, i.e., planning water-related activities at the scale of the catchment (the entire area from which water flows down to a single point such as the river mouth). Catchment-based management ought to include both technical and planning interventions. Other necessary measures include: optimisation of the water management system, precise allocation of competences, anchoring the local and regional strategies in hard data and forecasts, and establishment of streamlined communication, information and education systems. One such initiative to support bottom-up initiatives focusing on local water management in agricultural areas was the idea to set up Local Water Partnerships, embraced in 2020 by the Ministry of Agriculture and Rural Development and the Agricultural Advisory Centre in Brwinów, in collaboration with the Regional Agricultural Advisory Centres (Polish: *Wojewódzkie Ośrodki Doradztwa Rolniczego*).

In recent decades some farming practices (such as the industrial approach, use of monocultures and industrialised food production) led to a deterioration of natural resources and biodiversity loss. This is accompanied by an increasingly acute climate crisis, manifested by such phenomena as more frequent drought periods and falling groundwater levels. In parallel, a growing demand for food can be observed worldwide, and demand for ecological, high-quality foods is also on the increase in Europe. That is why it is now so important to initiate activities aimed at reversing unfavourable processes taking place in the agricultural landscape, in accordance with the EC's strategies: the Farm to Fork Strategy and the Biodiversity Strategy.

We need to promote and implement agriculture based on an understanding of agricultural landscape processes in order to adapt to climate change and restore the processes that naturally occur in the environment. The agricultural sector needs to change its approach and aim towards a sustainable resource management, implementation of mechanisms to improve biodiversity, containing biogenic substance losses, and in consequence striving to put to life processes to enable production of high-quality foods in the context of public health.

A Summary

The monograph also offers a broad look at *Economic aspects of the EGD implementation in the conditions of Polish agriculture – strategies and programmes of action*. The world's increasing population, mainly in Asia and Africa, combined with the growing affluence of many nations living on these continents, is leading to a spike in the demand for food. It goes without saying that more people need more food; but also, due to increasingly affluent societies, the demand for better-quality foods, particularly of animal origin, is on the increase in many developing countries.

It is widely agreed that the land under cultivation practically comprises all land that is fit for agricultural use. Any further increase in the area of land used for agriculture would mean the use of land only marginally suitable for agricultural production (such as dry areas, wetlands) or rainforest clearing.

Yet, at the same time, further expectations are being placed on agriculture, such as: improving the health quality of produced foods; reducing greenhouse emissions and use of certain industrial inputs (mineral fertilisers, PPP, antibiotics); curbing water consumption; improving the welfare of farm animals or preserving biodiversity. Some of them are well-justified. In addition, consumers widely expect food to be at least relatively inexpensive. In many less-developed countries, low prices of agricultural produce are prerequisites of food to be economically available.

As we can see, agriculture needs to meet the ever-increasing and more and more diverse requirements, having at its disposal the same, if not decreasing, area of farmland. In other words, it must satisfy the growing demand for food, fodder, energy and raw materials used outside the food industry without reducing agricultural production, yet, while preserving biodiversity, manifesting consideration for the environment and meeting the expectations to reduce yield-increasing inputs (PPP, mineral fertilisers).

The challenges that agriculture is currently facing do not have simple answers. Although undoubtedly no return to the past is possible, some of the best farming practices could be re-introduced on a wide scale. Similarly, no straightforward continuation of the current development path is possible either.

The potential global-scale solutions need to fall within one of the two main directions, that is: (1) cutting down demand for goods produced by agriculture, and/or (2) increasing productivity in agriculture, i.e., producing more goods while using similar if not fewer resources and outlays, or by using alternative resources (e.g. technological development or new technologies and methods of production).

Demand can be scaled down by modifying human behaviour: making dietary changes, reducing wastage of agricultural produce and ready-to-eat foods on the one hand, and on the other, reducing the birth rate. Successes in these areas could slow down the rate at which demand for food is growing, but are not likely to put a halt to this process. Therefore, for the coming several decades, global food production will need to rise.

It is also widely agreed that agricultural development ought to be sustainable. However, how the term is understood in agricultural and political practices is far from clear-cut. For the past several decades, the EU's Common Agricultural Policy (CAP) has been the political forerunner of the concept of sustainable agriculture. Its outcome is the so-called European model of agriculture, which comes closest to the concept of such agriculture worldwide because it is economically viable; ensures food security for EU citizens at a good quantitative and qualitative level, and evolves with consideration for environmental requirements.

One way to tackle the challenges facing EU's agriculture is to incorporate them into the EGD. Within this programme agriculture would be shaped mainly by two strategies: (1) the Farm to Fork Strategy, and (2) the Biodiversity Strategy.

Polish agriculture represents part of European and global agriculture but has its own inimitable characteristics. Therefore, the premises for EGD implementation will be influenced by global processes and European determinants (including the CAP) on the one hand, and the specific attributes and conditions of Polish agriculture on the other.

Polish agriculture is relatively ill-prepared to responding to the challenges imposed by the EGD. It is noted for a higher than average use of nitrogen fertilisers and a heavy use of phosphate and potassium fertilisers. However, cutting down on their consumption may result in a greater fall in production than that in the agricultural sectors in Western and Southern Europe. In Poland, the productivity of agricultural holdings is among the lowest in the EU. This can be attributed to a high level of agrarian fragmentation, lower soil quality and shorter vegetation period than in Western European countries. Consequently, the use of mineral fertilisers will have to be stepped up in order to maintain competitive productivity of agriculture at the EU scale.

Analyses of the impact of EGD implementation on European and Polish agriculture suggest that a lack of suitable preparedness for its implementation may bring about far-reaching negative consequences for EU food consumers and for its agricultural sector. In Poland, a report was commissioned by the Polityka Insight analytical service, entitled *The impact of the European Green Deal on Polish agriculture*. Its authors estimate that if the EGD is implemented in its entirety, the aggregate value of production of the main analysed crops could fall by 13%. Such a reduction in production would mean an 11% decrease in farmers' income. This, in turn, would mean that food security and economic food availability would deteriorate. In addition, the balance of foreign trade in agri-food products would also worsen, not necessarily producing evident environmental gains.

Introducing the EGD into agriculture in a manner that would produce negative results cannot be acceptable. This does not mean, however, that the very concept of the EGD ought to be evaluated negatively or completely rejected. The basic path for EGD implementation in agriculture and also an answer to a reduced use of yield-increasing inputs (fertilisers and PPP) is what we call precision agriculture, which is the application of state-of-the-art technologies and methods to offset the reduced quantities of fertilisers and PPP with their better effectiveness. This would help substantially decrease the quantities and costs involved in the use of fertilisers and PPP.

Nonetheless, due to Poland's extensive agrarian fragmentation and relatively scant technical and financial resources available to a large proportion of farms, introducing precision agriculture methods is bound to be much more difficult than in Western European countries. The authors of the aforementioned report on the impact of the EGD on Polish agriculture concluded that, for technological and economic reasons, precision agriculture can be employed in agricultural holdings with over 50 ha of arable land. There are about 40,000 holdings in this category, which farm about 35% of total arable land. In other EU countries with a similar – and thus competitive – structure of production, farms with 50 ha or more tend to hold 80% to as much as 90% of arable land. For this reason, agricultural policy should not overlook large and bigger farms where the use of precision agriculture measures would be justified both technologically and economically.

A Summary

The introduction of precision agriculture requires farms to make a substantial capital expenditure and ensure a sufficiently large scale of production. Therefore, adapting agriculture to meet the EGD requirements, particularly the Farm to Fork Strategy, which is crucial for the sector, is a cost-intensive task; it also entails a number of risks jeopardising the competitiveness of agricultural production, and as a result, could potentially reduce farmers' income.

Nevertheless, a skilful implementation of the strategy and well-addressed investment support for agriculture could help bring about economic and environmental gains while maintaining, if not increasing, production levels. This issue has become particularly visible given the massive rise in the prices of gas and other energy resources. In the present situation brought about by the war in Ukraine, but also looking further into the future, cost-effective and energy-efficient agricultural production is a must. This means that even without the EGD initiative, environmental and climate issues and the political situation would also render the challenges expressed in the EGD highly pertinent.

Agriculture – in Poland and elsewhere – calls for processes that will comprise both development (production and productivity), as well as structural and technological transformation. Therefore, it needs to expand the research and technological potential in order to promote sustainable development in the farming sector and make a more extensive use of knowledge from various scientific disciplines. The development of agriculture ought to rely on knowledge and state-of-the-art technologies as its main inputs. Application of modern technologies is a precondition for striking a balance between ecological, economic and social objectives; only a smart direction of the transformation will safeguard food security and safety, and render agricultural production environment – and climate – friendly.

The monograph's last chapter is entitled *Strategies for the financing of the European Green Deal*. The economic changes that took place over the last centuries and accelerated rapidly in the wake of World War II, have brought increased affluence and improved quality of life for a substantial portion of humankind. This was achieved in a period of unprecedented and accelerating population growth. However, in many cases, technological progress and economic growth were marred by increased pressure on the environment.

The European Union responded to the challenges at the intersection of the economy and the environment by placing a steadily growing emphasis on ecological issues in its policies, which have now found their consummation in the introduction of the European Green Deal. The EGD is an EU-wide political strategy that sets out to tackle the mounting environmental problems and climate change. Its objective is, first and foremost, to achieve climate neutrality by 2050. The EGD encompasses all sectors of the economy and requires considerable public funding for its implementation. It also assumes that its positive social and economic effects will be the creation of new jobs in projects pursuing the 'green transformation'.

It was originally agreed that in 2019 the financial support for the EGD implementation would come from the EU budget, which is essentially from the funds allocated as part of the Cohesion Policy and the Common Agricultural Policy. The year 2020 saw the outbreak of the Covid-19 pandemic, which led to serious losses in Member States' economies. In response, the EU set up another, ad-hoc programme outside the 'traditional' EU budget, termed NextGeneration EU (NGEU). After the pandemic, European economies were also to be bolstered by pursuing projects contributing to wide-ranging 'green transformation'. It can be said, therefore, that in practice, all of the EU funds (Cohesion Policy, CAP and NGEU) are providing financing to the EGD.

The European Green Deal extends to many sectors of the economy, including:

- transport
- construction
- energy
- environmental protection
- healthcare
- agriculture.

The aggregate value of funds in the 2021–2027 financing perspective totals over EUR 2 billion, of which 60% is allocated under the Multiannual Financial Framework (MFF), and 40% represents the one-time resources of the NextGeneration EU. Since the NGEU aims to enable the recovery of the European economies after the crisis induced by Covid-19, the bulk of the funding is earmarked for the EU budget heading *Cohesion, resilience and values* and, to a lesser degree, for *Single market, innovation and digital*. Both these headings fall within the EU's Cohesion Policy, which altogether (including the MFF budget) accounts for nearly 67% of the total allocation. The Common Agricultural Policy is funded under the heading *Natural resources and environment*, which represents slightly over 21% of the budget, with the majority of the funds coming from the MFF. The remaining expenditure is of lesser importance.

The NGEU offers funding for seven programmes, notably the Recovery and Resilience Facility (grants and loans), an instrument that accounts for close to 90% made available under the NGEU. In some cases (Horizon Europe, Just Transition Fund, Rural Development), the NextGeneration funds only add to, or supplement the MFF funding.

Not all of the programmes funded or co-funded under the NGEU are allocated at the national level (Member States). For instance, the Horizon Europe funding is awarded to applicants through calls for proposals. Where national allocation is in effect, the volume of allocated financing depends on a number of factors, related either to losses incurred during the pandemic or to specific requirements associated with the implementation of the European Green Deal.

The Recovery and Resilience Facility provides ca EUR 338 billion in grants for national recovery plans. The biggest allocation has gone to Italy and Spain as the countries that were particularly acutely affected by the pandemic. Relatively substantial support has also been planned for Poland, which is to receive nearly EUR 24 billion, i.e., slightly over 7%.

Much more modest funding was allocated to the ReactEU programme – less than EUR 40 billion. In this case, Spain and Italy have received the largest budgets (over EUR 10 billion apiece), also on account of the losses they incurred as a result of the pandemic. Poland can expect relatively small support under that programme (ca EUR 1.7 billion).

In the years 2021–2027, the European Union intends to earmark over EUR 378 billion to agriculture and rural areas. The bulk of this sum is allocated via the Multiannual Financial Framework, mainly the European Agricultural Guarantee Fund which finances CAP Pillar I, i.e., mostly direct payments. Its budget totals over EUR 282 billion, that is nearly 78% of the aggregate allocation for agriculture and rural areas.

A Summary

The NextGenerationEU funds are of marginal importance (EUR 8 billion, i.e. 2.1%); they provide co-financing for structural measures implemented in rural areas, most of which, however, remain within the remit of the European Agricultural Fund for Rural Development (EUR 87 billion, 23%). France is the largest beneficiary in that area of support (over EUR 66 billion, i.e. 17,5%), mostly due to the funding it receives under CAP Pillar I. Poland's allocation totals ca EUR 32 billion, i.e. 8.5%.

The budget of the Just Transformation Fund is made available by the NextGenerationEU (nearly EUR 11 billion, 56%) and the MFF (EUR 8.5 billion, 44%). In this case, Poland is the biggest potential beneficiary due to the country's substantial needs regarding the decarbonisation of its economy.

The overall Cohesion Policy budget totals nearly EUR 370 billion. The bulk of its funds (ca 58%), is allocated to the European Regional Development Fund. Since the moment of its EU accession, Poland has been the biggest Cohesion Policy beneficiary, and will remain so in the 2021–2027 financing perspective. The allocation set for Poland in that period exceeds EUR 75 billion, of which EUR 47 billion comes from the European Regional Development Fund.

The total EU budget for 2021–2027, which comprises the Multiannual Financial Framework and the NextGenerationUE (without its loan arm) is over EUR 1 trillion. These include only national allocations and exclude the funds with no such allocations (such as Horizon Europe). The financing structure for this programming period is not typical because of the one-time NextGenerationEU fund, which, however, accounts only for 21% of the total budget. The remaining portions of the budget include the Cohesion Policy, which accounts for as much as 56% of total funding, and the Common Agricultural Policy (mainly with its Pillar 1, i.e., direct payments), which represents 23%.

The biggest beneficiaries of the aggregate budget are Spain and Italy, mostly due to their largest allocation under the Recovery and Resilience Facility. Support for each of these totals over EUR 160 billion, which accounts for ca 14% of the total budget. Poland is the third biggest potential beneficiary, with an allocation exceeding EUR 136 billion, i.e., nearly 12% of all the funding. In this case, the Cohesion Policy has a special role, given that Poland has been the largest recipient of its funds among the EU countries.

The operational programmes under the Cohesion Policy and CAP show a remarkable continuity with respect to their scope. Therefore, one might get the impression that, in this context, the EGD merely provides a structure for the earlier-defined EU policies. This is partly true, especially if we consider the fact that for a long time both these policies have been targeted – to a lesser or larger extent – at environmental issues. Besides, the EGD is a rather broad concept that puts ecological issues at its very heart, but is not limited to them. This is because it was rightly assumed that the impact of the economy on the environment cannot be lessened at the expense of economic growth. Hence the EGD's principal focus falls on such issues as energy efficiency, energy transformation and the necessary innovations it involves.

The Foundation for the Development of Polish Agriculture (FDPA) is a nongovernmental organisation with traditions dating back 35 years. Our mission is to support the sustainable development of rural areas, in particular, enterprise and the creation of jobs outside agriculture, and to ensure equal opportunities for women, the unemployed and young people. To this end, as one of the most active and largest loan funds in Poland, we engage in loan activities and services fostering the development of small rural enterprises.

We take part in local development programmes, community initiatives, information and education schemes. We also publish respected studies and specialist reports such as the biannual report on the state of Poland's rural areas (latest edition: *Polska wieś 2022. Raport o stanie wsi*) and numerous publications to promote the sustainable development of rural areas that deal with issues such as adaptation to climate change and effective resource management.

Since 2009, we have regularly organised a contest entitled *Rural Poland – the Legacy and the Future* for scientific and popular-science works on agriculture and rural areas and those that promote their history and cultural heritage. We initiated debates held as part of the cyclical event entitled *Rural Poland in the 21st Century*. We have also organised many international, domestic and local projects addressed to rural residents, farmers, local governments, agricultural advisory centres, public institutions, and small and medium-sized entrepreneurship.

Foundation for the Development of Polish Agriculture
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The reviewed monograph is the first Polish publication which tackles agriculture and environmental issues associated with the rollout of the European Green Deal. As such, it presents a valuable contribution to the body of knowledge about sustainable agriculture.

Prof. Robert Kupczyński

Nearly all components of the European Green Deal (EGD) – a new EU strategy aiming to make its economies more environmentally oriented – have direct or indirect links to agriculture. The monograph offers a multifaceted perspective, both scholarly and practical, on issues associated with the implementation of the EGD, in the context of the state of natural resources and processes taking place in agricultural production.

Prof. Agnieszka Baer-Nawrocka

The monograph is the first of five volumes compiled as part of a project titled *European Green Deal – Opportunities and Challenges for Polish Agriculture*, administered by the Foundation for the Development of Polish Agriculture (FDPA). The papers included here were originally presented at seminars focused on formulating guidelines for the implementation of the EU's new scheme, European Green Deal (EGD), through farming practices aiming to enhance opportunities for the development of Polish agriculture.

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