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The Impact of Climate Change on Agricultural and Rural Development by 2030

Abstract: Climate change is one of the greatest challenges of the modern world. In the long-term perspective, mankind must achieve climate neutrality in order not to lead to a breakdown in the development of civilization. This requires significant mitigation efforts to reduce greenhouse gas emissions. Over time, when the climate change is more affecting human life, adaptation measures are also needed. Some countries, including members states of the European Union, are making efforts to achieve the goal of climate neutrality. It involves a significant financial and organizational effort. The aim of the article is to indicate changes in agriculture and rural areas that may take place in the perspective of 2030 as a result of the climate change and the application of mitigating and adaptation policies. The article was written on the basis of the available literature.

Keywords: climate change, agriculture, rural development, future studies.

1. Introduction

The world is in the period of transition. Change is a concept that is virtually an integral part of contemporary times. The pace of technical progress and related opportunities is so high that, in many cases, we cannot keep up with the changing circumstances. What is more, it is estimated that these processes will mark the upcoming decades on a global scale.

In literature, the contemporary times are defined as a civilisational turning point comparable to the early ages of the industrial revolution (Kleer 2018; Toffler 1984). However, currently the impact range and speed of the changes are much higher. In practice, we can distinguish two overlapping turning points (Kleer 2019). In highly developed countries, we observe a transition from industrial civilisation to a new form, whose name is not clearly defined but is often described as post-industrial civilisation or the civilisation of knowledge. Meanwhile, in the developing

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countries, we observe a transition from agricultural to industrial civilisation with elements of post-industrial civilisation. These two processes are causing very serious changes that concern not only the technology of production, methods of trade or institutional changes, but also make us completely rebuild our thinking about the world, additionally causing a change in mentality and social relations. In practice, both transitions significantly affect agricultural production.

At the same time, such deep processes feature a long period of changes and the absence of a clear development path. If we talk about the transitions currently being observed, we probably deal with processes that will last for decades, and we are unlikely to precisely indicate where they can lead us. For example we cannot predict the institutional changes that will result from the processes of integration and globalization. We cannot also predict even major changes in economy. On the one hand, some decisions indicate that highly developed countries are turning towards sustainability and greater care for the environment, and on the other hand, we are observing an increase in consumerism. These two trends contradict each other in the long run. We are not able to estimate which one will be stronger.

There is no doubt that one of the principal forces of contemporary progress lies in technological changes related to information and communication technologies. In addition, the environmental factors are becoming more and more important, especially climate change, which considerably affects the quality of human life, the availability of natural resources, and the stability of ecosystems. Contrary to the common opinion that human life is separate from environmental conditions owing to universal electrification and mechanisation, it is becoming clear that the local and even global pressure of humans on the environment is so strong that it is destabilising the conditions of human life, forcing us to adapt to changes (Conway 2012; Martenson 2011). For many years, this approach has been denied (von Weizsäcker and Wijkman 2018), and the issue has been put off to be solved by subsequent generations, but currently the changeability of environmental conditions is so great that, in many cases, we can notice it with a naked eye without having to conduct any specialised research. The impact of the environment, particularly the climate, is and will be noticeable in various areas of human activity, and will affect people regardless of whether they live in urban or rural areas. An important issue here is a close relationship between agriculture and environmental conditions, which makes rural areas considerably more exposed to the effects of environmental changes than it seems.

In this paper, the author raises the issue of climate change as the most important of the environmental factors mentioned above, and attempts to indicate the principal changes which this may cause to agriculture and rural areas in Poland. The deliberations take the perspective of the upcoming ten years, that is until

2030. It is only a segment of mentioned period of civilisational turning points, so long-term trends are difficult to notice, but certain symptoms of those changes already seem clear.

2. Climate changes in Poland by 2030

The contemporary climate changes are anthropogenic and caused by increasing concentration of greenhouse gases (GHGs) in the air (IPCC 2007). For this reason, our priority is to reduce the emissions of those gases. However, emission reduction should not be expected to solve the problem of climate change. Even an immediate implementation of climate neutrality[1] (which is impossible in practice) will only result in greenhouse gas concentration remaining at current levels, which means that temperature will slowly continue to rise (IPCC 2013). We should also remember that climatic processes feature a high level of inertia. Processes that are started now will have effects in many years to come. Some of these processes may remain unnoticed in the perspective of the ten years under analysis (IPCC 2013).

In practice, even the most optimistic long-term projections predict a further increase in atmospheric GHG concentrations and increasing rates of climate change (IPCC 2013). The differences between different scenarios arise from the estimation of greenhouse-gas emissions.

From the climate point of view, a ten-year perspective is a very short time. Given the probability of annual or even multi-annual anomalies, forecasts for such a period may deviate from the determined average. For this reason, climate change is usually projected for several decades. Such scenarios, prepared by the Institute of Environmental Protection – National Research Institute, have been used in this study. They were prepared as part of the Klimada 2.0 project (2020).

These projections are presented as two scenarios: RCP4.5 and RCP8.5. The moderate RCP4.5 scenario assumes "a further increase in CO_2 concentrations to 540 ppm in 2100, and a radiation force input of 4.5 W/m^2, while the extrapolation scenario (RCP8.5) corresponds to CO_2 concentrations increasing to 940 ppm in 2100, and a continued increase in radiation force input to 8.5 W/m^2" (Strużewska et al. 2020, p. 10).

No abrupt climate change is expected in the upcoming decade, but current trends should be maintained.[2] Historical data show that the average annual temperature in the 21st century was higher than the average in 1981–2017 (Strużewska et al.

[1] The concept of climate neutrality means that the level of GHG emissions in a given area is equal to the capacity to absorb them.

[2] This approach depends on how the climate change is perceived. On the one hand, scientists claim that the current rate of climate change is the fastest one known to mankind, and on the other, from a human

2020). In that period, the number of hot days rose (from several to more than ten per year), and the number of frost days decreased, by 25 days on average. The total rainfall rate has also increased.

The forecasts of key climatic factors are shown in Table 1. The results lead to interesting conclusions. First, there is no significant difference between the scenarios during the period under analysis. This will continue until more or less 2040. Many results acquired within scenario RCP8.5 will even be lower than those for RCP4.5. This means that the change will be slower than in the milder scenario. The differences may be caused by the assumptions made in each scenario. Nevertheless, we should emphasise that they will be irrelevant in the 2030 perspective.

Table 1. Climate-change projection for Poland in 2021–2030 as per scenarios RCP4.5 and RCP8.5
Tabela 1. Prognoza zmian klimatycznych na terenie Polski w latach 2021–2030, wg scenariusza RCP4.5 i RCP8.5

Indicator	RCP4.5		RCP8.5	
	Quantity	Change compared to 2006–2010	Quantity	Change compared to 2006–2010
Annual average temperature [°C]	9.082	+0.637	9.070	+0.471
Number of frost days with a minimum temperature below 0°C	88.56	-8.78	90.01	-7.92
Number of days with a temperature above 30°C	9.86	+2.73	8.24	+1.46
Number of vegetation days with an average annual temperature above 5°C	248.21	+7.24	246.67	+7.72
Annual precipitation [mm]	730.0	+22.1	726.2	+11.7

Source: Own study based on Klimada 2.0 project (Klimada 2.0 2020).
Źródło: Opracowanie własne na podstawie projektu Klimada 2.0 (Klimada 2.0 2020).

In general, the changes observed in this period are not great, but they continue the current trends. Increasing temperatures will cause longer vegetation days, more hot days, and fewer frost days. For Poland, it is assumed that for the year 2030 compared to 2000 this will be extended by 16 days (MŚ 2013). This implies that winters will be milder, while in summer extreme weather phenomena will be more likely. However, these changes do not exclude anomalies – even during a mild

perspective, the processes are too slow to be noticed by the naked eye. In addition, projections show that the rate of climate change will accelerate after 2040 (IPCC 2013).

winter, there may be short periods of severe frost, and a summer may be cooler than usual (Meehl et al. 2007; Westra, Alexander and Zwiers 2013).

In terms of water availability, it is noticed that the annual rainfall and the number of days with rainfall are rising (Konca-Kędzierska 2019). This is only apparently positive, as at the same time it has been observed that the greatest increase in precipitation will occur for heavy rainfall, i.e. with a daily precipitation rate higher than or equal to 20 mm (Strużewska et al. 2020). Such rains are damaging for the economy and, in particular, for agriculture. A sudden rainfall implies a rapid subsurface runoff, which can be accompanied by water erosion and does not cause any significant soil irrigation, as water quickly flows down to lower areas and does not have time to soak into soil. The increasing rainfall will therefore have a moderate impact on agriculture. Given the simultaneous rise in temperature with its side effect being increased evaporation, the availability of water for agriculture may actually fall. Observations within the Agricultural Drought Monitoring System show that in recent years problems with water availability have been increasing. In the last decade, agricultural drought in Poland was recorded five times, i.e. in 2015, 2016, 2018, 2019 and 2020 (IUNG 2020).

3. Agriculture versus climate change

Given the scale of its direct impact and the indirect effects it produces, climate change is deemed to be the greatest contemporary environmental challenge. In consequence, it is not only the problem of rising temperatures but of a number of factors that affect climatic conditions in a given region. Climate change, for instance, has an impact on air humidity, the number of vegetation days, water availability, and the occurrence of extreme meteorological phenomena (droughts, hurricanes, floods). These phenomena profoundly change ecosystems, which causes even more serious adverse effects.

In the context of agriculture, climate change affects not only the conditions for plant vegetation (Wypych et al. 2017), but also indirectly brings changes in other key agricultural production factors, i.e. soil and water. In addition, climate change leads to the degradation of biodiversity, which affects areas such as the availability of pollinators, organisms that are essential for allogamous plants to produce food (FAO 2011). It is estimated that around 35% of food produced in the world depends on pollination by insects.

In the case of Poland, climate change entails a longer growing season and a higher plant growth rate. Both factors cause an increased demand for water. The information provided shows that the amount of rainfall, as the main source of water supply for agriculture, will increase. However, this will not improve water

conditions for agriculture. Data shows that there will be more violent meteorological phenomena, such as downpours or even floods (Konca-Kędzierska 2019). This is due to a faster subsurface runoff and a lower water absorption by soil. In addition, warmer winters imply a lower capability to store water in the form of snow, so there will be less water in the spring when it is required. Water availability may affect water management on farms and the choice of crops.

The extension of the growing season increases the risk of pests. Until now, the emergence of pests (mainly insects) has been correlated with the migration of their predators (mainly birds), which has allowed us to maintain a relative equilibrium. Accelerated vegetation of plants resulting from increasing temperature may cause earlier activity of pests. At the same time, the migrating predators feeding on them may not have sufficient time to reach the country (Thackeray et al. 2010).

Climate change may result in accelerated soil erosion (Sharratt et al. 2015). This can be both water erosion (as a result of increased runoff during rainstorms) and air erosion caused by the increasing risk of high winds or even hurricanes. Winds may also cause damage to farming infrastructure, including buildings. It is anticipated that this could lead to increased costs of construction and insurance.

The effect of increasing temperature on crop yield is dubious. On the one hand, we observe a decline in the yield of many crops (Abrol and Ingram 1996; Hatfield and Prueger 2015; Wang et al. 2011), and on the other, shifting climate zones will increase the availability of new agricultural land, mainly in northern countries, and above all in Canada and Russia (IPCC 2013; Randers 2012).

Climate change is also a problem for livestock production, affecting it both directly and indirectly. Changes in ambient temperature have a direct effect on factors such as animal metabolism (Babinszky, Halas and Verstegen 2011). The effect of increased temperature may also slow down growth, reduce milk productivity, conception rates and appetite, and even cause rising mortality (Cho et al. 2011). Indirect effects include difficult access to water on pasture land, increased costs and availability of feed and the cost of maintaining adequate temperature in buildings (Nardone et al. 2010).

4. Counter-measures to changing circumstances and the future of rural areas and agriculture

The magnitude of climate change generates an urgent demand for remedial measures. Nowadays, it is believed (IPCC 2014) that these should be of two different types: mitigation (reduction of GHG emissions) and adaptation (adjustment to the anticipated changes). Both processes should be implemented simultaneously; however, we must emphasise that without effective mitigation the problem of

climate change will not be solved and the change will even accelerate. Adaptation should therefore be treated as a subsidiary process that is only effective if we reduce GHG emissions. However, it is necessary, given that climate change is progressing.

Experience shows that pure market forces cannot overcome the challenge. Even if the number of climate change deniers is decreasing, the will to make changes and pay the associated costs is still low. In addition, bottom-up actions are usually taken only in the area of adaptation and not in the area of mitigation. For this reason, institutional intervention that uses various mechanisms to enforce emissions abatement is necessary.

Agriculture is one of the major sectors responsible for greenhouse-gas emissions. Globally, its share is estimated at around 20% of total emissions (FAO 2020; IPCC 2019). In Poland, at 14% (Eurostat 2020), the agriculture, forestry, hunting and fishing sectors together were the third largest GHG emitter in 2018. Only the energy (41%) and industry (18%) sectors emitted more. This makes the agriculture very important for climate policy.

If we take the perspective until 2030 and the agricultural changes in Poland, it seems that environmental policy, in particular climate policy, will be a contributor to the largest changes. Poland is a signatory to the 2015 Paris Agreement (UNFCCC 2015), which imposes an obligation to achieve climate neutrality in the long term. The European Union, of which we are a member, has begun to implement these provisions and announced its target to achieve climate neutrality by 2050. Moreover, in strategic documents it has considerably intensified the work on the implementation of sustainable development principles to the economy, in particular to agriculture. This is proved by the new development strategies of the European Union, i.e. the "European Green Deal" (EC 2019), "From Farm to Fork" (EC 2020a), and "Bringing nature back into our lives" (EC 2020b) – Biodiversity Strategy by 2030.[3] The new structure of the Common Agricultural Policy, which now gives more importance to environmental objectives, also shows a significant change in thinking about agriculture, the aim of which is no longer only to ensure adequate food supply but also to care for sustainable development of rural areas. A new European Union Climate Strategy is also in the pipeline, which provides for intensified activities. This is evidenced by the creation of a new Community law section, the European Climate Law, which should be enacted in mid-2021.

These activities are part of the civilisation turning point mentioned in the introduction. The European Union's ambitious goals for 2050, i.e. to achieve climate neutrality and build a sustainable economy, show this very clearly (EC 2018). Jerzy

[3] The objectives assumed in these strategies and the related challenges are discussed in more detail in the article (Wrzaszcz and Prandecki 2020).

Wilkin (2020) claims that these actions are giving rise to a new green revolution. It is difficult not to agree with him. The decisive steps defined in the strategy documents for the next decade are revolutionary. Their implementation will be a great challenge not only for agriculture in Poland. However, the changes are required to keep humans safe.

In short, the European Union aims to build a new economic architecture with the goal of building a modern, resource-efficient and competitive economy that will reach zero net greenhouse-gas emissions in 2050, and economic growth will be decoupled from the use of natural resources (EC 2019). This general goal shows that climate policy will play a leading role and that agriculture, as one of the main sectors responsible for greenhouse-gas emissions, will have to make fundamental, revolutionary changes.

The philosophy behind these changes is set out in the strategy titled "From Farm to Fork" (EC 2020a), which, taken together with the Biodiversity Strategy by 2030 (EC 2020b), is a central point in the concept of the "European Green Deal". The aim is to create a fair, healthy and environmentally friendly food system where any food produced should be safe, nutritious, of high quality, and produced with environmentally safe and climate-neutral methods. The aim is to promote sustainable farming based on family farms, to reduce the use of artificial fertilisers and plant protection products. An important component of the EU's new approach to development is the high integration of strategic documents. In practice this means that, for agriculture, the goals to be achieved in 2030, included in the strategies mentioned are equal. This does not cause any problems with the interpretation of regulations, and at the same time it forces us to think about agricultural production as a component of a complex system.

From the Polish point of view, the most ambitious targets result from changes in climate policy. In this regard, specific solutions still remain unknown. Moreover, there is an ongoing discussion about the shape of climate policy. So far, it has rested on two pillars: the market and politics. The market pillar is formed by the EU Emissions Trading Scheme (EU ETS), which covers large economic operators. This is the main tool for reducing emissions in the EU, but does not cover agriculture, where reduction is based on a system known as non-ETS. Under this framework, decisions are made on the basis of political agreements between member states, and emissions are reduced mainly through administrative rather than market-based solutions. The new shape of climate policy is not yet agreed (as of January 2021), but one of the proposals being discussed is to spin off a third pillar that would include the agriculture sector and LULUCF (Land Use, Land Use Change and Forestry) (EC 2020c). It is unknown whether this will be implemented, but the mere discussion on the subject shows the importance of the role of agriculture

in climate policy and the seriousness of the changes in that sector in the context of climate policy.

What is already known is the GHG emissions reduction target for the period up to 2030. On 11 December 2020 the European Council (EUCO 2020) agreed that a new 55% reduction target for greenhouse-gas emissions compared to 1990 would replace the current target of 40%. This objective is only general, and it is not yet clear how it will be distributed among individual mechanisms. It can be assumed that the EU ETS sector will set a more ambitious target, while the non-ETS sectors will show a lower emissions abatement. In addition, the Council decided to introduce a carbon tax that would be levied on goods imported to the European Union, with the aim of levelling out the rules of competition and preventing carbon leakage outside the EU.

The existing reduction target was 40% compared to 1990, which for the non-ETS sectors meant that emissions had to be reduced by 30% compared to 2005. The target has not yet been distributed evenly across countries, which follows from the reduction potential and the advancement level of a given sector. In the case of Poland, the target was a 7% reduction by 2030. It was widely accepted that it was very ambitious for Polish agriculture. The current increment in the main target must entail increasing the reduction targets for each sector. It is estimated that for non-ETS the reduction could be 48%, and for Polish agriculture, even 16% (CAKE 2020). Such changes are revolutionary, especially if we consider that until 2020 Poland was entitled to increase emissions in the agricultural sector.

A new approach to agriculture as part of an integrated policy of sustainable development requires not only the implementation of ambitious targets, including reduction targets for GHG emissions, but above all a change in mentality and the way of thinking about the environment. Convincing the rural population that agriculture is an element of a larger entirety, which is the ecosystem of planet Earth, will require a major effort, as it will often involve changing agricultural practices that have been used for decades and are therefore already part of the agricultural tradition. An example of this is grass burning in spring: although banned for many years, cases of this irrational activity still occur.

In Poland, the implementation of European climate goals will be hampered by the dispersed structure of agriculture, i.e. a large number of entities and relatively small farms. This requires not only the implementation of specific solutions aimed at such small entities, but also an appropriate system for monitoring and reporting changes in emissions. Due to the method adopted, the present reporting system does not practically take into account the efforts made on farms. The new Common Agricultural Policy requires member states to show measurable effects of their

actions, which will have to be correlated with reports at the level of greenhouse-gas emissions.

As indicated earlier, adaptive processes are easier to carry out, as they are a response to the immediate threats. For this reason, these actions will be taken on an individual basis, i.e. implemented mostly bottom up by individual farmers or their associations. Larger infrastructure projects will be implemented by local governments or even central authorities, but we should expect that the scale of such solutions will not be large, given the budgetary limitations and the priority of mitigation activities. Interest in adaptation measures will increase slowly along with the growing awareness of the risks and the nuisance they cause. It is reasonable to assume that these processes will begin to develop in the second half of the projected decade.

Agriculture is still the important source of income in rural areas, hence its importance, including the importance of environmental factors for rural development. However, this may not be the only reason of the actions forced by climate change in rural areas. For example, developments in rural areas are scattered, which implies greater exposure to extreme meteorological phenomena, mainly hurricanes, which tend to reach higher speeds and destructive force in open areas. This contributes to potentially higher property losses, and construction will have to be adapted to the growing risk of such events. Similarly, reduced water availability may cause the demand for new, deeper water intakes.

Unlike in urban areas, in rural areas local cooperation and development based on common goods will be of greater importance. In cities, infrastructural changes are largely dependent on local and central authorities, which are required to undertake various types of tasks. For rural communities, a limitation will be the budgetary capacity of local governments and their ability to respond to changing circumstances. For this reason, various types of solutions to adapt to changing conditions may depend on bottom-up initiatives taken by residents. One such action may be the return to small retention in the form we know from several decades ago, i.e. the construction of local storage reservoirs accessible to the entire community. In the second half of the projected decade, we can also expect a more dynamic use of renewable energy sources in rural areas. The solutions will be both individual and collective, i.e. intended for communities. Their importance will grow given the increasing risk of interruption or deterioration of transmission networks, which already cause many problems with the proper operation of advanced equipment.

5. Conclusions

Climate change in Poland will cause threats noticeable in a perspective that is much longer than ten years. We can already see the first adverse effects of these processes. It seems that they will force farmers to take certain adaptive measures. However, if climate issues are to be addressed effectively, mitigation and adaptation activities must be taken in parallel.

Actions to reduce GHG emissions are taken based on institutional arrangements. Poland, as a member of the European Union, is also required to make efforts aimed at emission reduction, which in the sphere of agriculture in Poland is to be implemented for the first time in the 2030 perspective. Climate targets are part of a broader policy covering sustainable agricultural development, implemented through a number of Community strategies. Their scope is such that we should speak of a new green revolution, with agriculture becoming part of a larger integrated entirety, and production objectives being treated equally as environmental objectives.

Such a change requires not only a number of actions aimed at developing and implementing new, low-emission agricultural practices, but also at building a system of education, monitoring of agricultural emissions, and related reporting. In the case of Poland and its large number of small farms, the construction of such a system is very complex but necessary to achieve the objectives assumed.

Furthermore, we should bear in mind that the targets for 2030 are only part of a larger reform which is to last until mid-century. This means that the efforts will be intensified in the coming decades.

The reforms introduced will induce a revolutionary change in rural areas, whose most important element will be a change in our mentality. Rural residents will have to accept that agriculture is not just about producing food but also about caring for the Earth's ecosystems and being responsible for the proper functioning of a number of environmental services, including the ability to absorb greenhouse gases. On the other hand, the changes introduced should aim at rewarding rural residents for the work they put into providing these services at the expense of their income. CAP reform is heading in this direction, and it should be assumed that it will intensify changes in the following years, i.e. in the second half of the decade.

To conclude, we can say that actions in agriculture, initiated by the need to counteract climate changes in the period exceeding the assumed ten years, may lead to far more complex transformations, taking into account social and economic relations on a scale defined as a civilisational turning point. The last two decades have shown symptoms of entering this new path of development. These were mainly limited to political declarations and gradual, subtle actions. The rapid acceleration

observed in the last two years allows us to conclude that the present decade may be different and more decisive, not only in Poland but also across Europe.

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Wpływ zmian klimatu na rozwój rolnictwa i obszarów wiejskich w perspektywie roku 2030

Streszczenie: Zmiany klimatyczne są jednym z największych wyzwań współczesności. W długookresowej perspektywie ludzkość musi osiągnąć neutralność klimatyczną, aby nie doprowadzić do załamania rozwoju cywilizacyjnego. Wymaga to podjęcia znacznego wysiłku mitygacyjnego, aby ograniczyć emisję gazów cieplarnianych. Jednocześnie wraz z upływem czasu i postępującymi zmianami klimatycznymi konieczne są również działania adaptacyjne, które pozwolą ludziom dostosować się do zmieniających się warunków. Niektóre kraje, w tym te należące do Unii Europejskiej, podejmują wysiłki, aby osiągnąć cel neutralności klimatycznej. Wiąże się to ze znacznym wysiłkiem finansowym i organizacyjnym. Celem artykułu jest wskazanie zmian w rolnictwie i na obszarach wiejskich, które mogą mieć miejsce w perspektywie roku 2030 oraz zastosowania polityk mitygujących i dostosowawczych. Artykuł został napisany na podstawie dostępnej literatury.

Słowa kluczowe: zmiany klimatyczne, rolnictwo, rozwój obszarów wiejskich, studia nad przyszłością.