

Article

Regenerative Agriculture as a Sustainable System of Food Production: Concepts, Conditions, Perceptions and Initial Implementations in Poland, Czechia and Slovakia

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Abstract: In order to produce agri-food products in a sustainable way, a new and pro-environmental farmer attitude to soil is of key importance. In a situation of significant degradation of agricultural land as a result of the spread of intensive farming, there has been growing interest in regenerative agriculture. Based on a literature review as well as quantitative and qualitative primary data, the authors aim to analyse various ways in which regenerative agriculture is defined, understood and implemented, with selected countries, namely Poland, Czechia and Slovakia, serving as examples. The objective of the study is also to recognise how and to what extent the concepts and practices of regenerative agriculture meet the principles of sustainable food production. An examination of the literature shows that regenerative agriculture is a relatively new and diversely described concept drawing on many models of agriculture. The results of a bibliometric and webometric analysis suggest that the scientific, expert and public perceptions of regenerative agriculture are still limited. In the countries under consideration, regenerative agriculture is often identified with the concept of biological farming (biologisation of agriculture), and the conscious implementation of its practices at farms is infrequent, usually only taking place at large farms. The study was conducted from the point of view of the social sciences and agricultural economics, is comparative in character, and includes recommendations for agricultural policy as well as guidelines for possible future research.

Keywords: regenerative agriculture; economic sustainability; soil; agricultural productivity; profitability of agriculture; Poland; Czechia; Slovakia; bibliometrics; webometrics



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1. Introduction

Today, agriculture fulfils many different functions, which include market and non-market production of environmental, social and cultural goods [1]. From this point of view, the agricultural sector, while ensuring food security and food safety, also contributes to environmental and energy security. In achieving economic, social and environmental objectives, the way in which the main agricultural resource, namely the soil, is used is of fundamental importance. However, the simultaneous production of food and energy in agriculture can be in conflict (i.e., a so-called food–energy competition). It is emphasised that, in the face of limited resources, especially agricultural land, the food and energy security objectives placed on the agricultural sector generally conflict with each other. For instance, demand for biofuels or biogas can limit agricultural production for food [2]. At the same time, agricultural production tends to be intensive and degrades soils and water sources and reduces biodiversity [3]. One way to avoid conflict and achieve synergies between the food, environmental and energy functions of agricultural production is through implementing regenerative agro-production systems, called agro-ecological symbioses [4–6].

As the food system changes, there has been a shift to new ways of land management and agrifood production. One of them is regenerative agriculture, which, in general terms,

means agricultural production based on “natural” methods and is closely tied with mechanisms occurring in nature, with a focus on measures fostering renewal and strengthening of the potential of natural resources used in agricultural production [6]. One might describe it as a set of principles in agriculture that serve viable, long-term, largely self-sufficient, self-renewing and environmentally friendly agricultural operations. In economically developed as well as developing countries where the agricultural sector has substantial economic importance, intensive forms of agrifood production that contradict many regenerative agriculture practices have predominated for a long time [7]. Estimates suggest that the intensification of agricultural production for food and energy purposes has contributed to the worsened condition of soil, the loss of biological diversity, increased greenhouse gas emissions, water resource exploitation and pollution, air pollution, poverty in the poorest countries, worsened health among the population as well as the monofunctionality of agricultural production in significant areas of the world [8–11]. For example, agriculture is estimated to account for 13.5% of global carbon dioxide emissions [12]. Also, as a consequence of intensive use of arable land and the increasing specialisation of production, the level of biodiversity has also decreased globally [13,14]. At the same time, a large part of farmed land is characterised by low organic matter levels [15,16].

Agricultural systems or practices contributing to the diminished potential (fertility) of soil, reducing the amount of carbon it contains or the number of living organisms in ecosystems has been termed “degenerative” [17]. Soil degradation caused by the pursuit of intensive agricultural practices also limits the long-term potential of agriculture for generating energy, liquid fuels and gas fuels from biomass [18,19]. Sustainable agriculture, its aim being to preserve natural resources, including soil, and to reduce the unfavourable impact on the natural environment while maintaining the vitality of farms, is often suggested as an alternative to intensive agricultural production. By comparison, regenerative agriculture is not just meant to help slow down the sector’s negative impact on the environment. By following appropriate farming practices, regenerative agriculture is supposed to help rebuild ecosystems, soil in particular, increase the potential of natural resources in the production of healthy foods and clean energy, boost naturally occurring processes as well as alleviating the effects of climate change [6,20,21].

Little has been said about regenerative agriculture so far, especially in the context of countries in East-Central and Eastern Europe [22,23]. In countries like Poland, Czechia and Slovakia, and also Russia, Ukraine and Kazakhstan, for instance, the term used interchangeably with regenerative agriculture or expanding its meaning over the past dozen years or so has been the “biologisation of agriculture”, while the concept of regenerative agriculture as such is not very familiar to either scientists or farmers [22–26]. At the same time, there is a lack of studies on the economic and environmental importance of regenerative agriculture in the production of food and in energy generation [6]. Agriculture in Poland has long seen a process of deteriorating soil condition (due to decreasing humus levels, strong acidification, water erosion, drying out and pollution, among other things), the average quality of soil being relatively poor due to the existing natural conditions [27]. In addition, the volume of energy generation from agriculture remains unsatisfactory and below the existing potential [19,28]. In Czech agriculture, studies show that conventional farms have the potential to increase the level of production sustainability by improving soil use, utilising energy from renewable sources and boosting biodiversity [29]. However, similar to agriculture in Slovakia, the level of environmental sustainability is among the highest in the European Union. Simultaneously, in the above-mentioned country, a significantly unfavourable change regarding physical soil degradation has been observed [30,31].

The aim of the present study was to analyse the concept of regenerative agriculture, outline its scientific and social perception, and also show how different stakeholders approach the implementation of this model, including large agricultural holdings in selected countries in East-Central Europe: Poland, Czechia and Slovakia. The second aim of the study was to identify to what extent and how the concept and practices of regenerative agriculture are useful for sustainable agri-food production. The concept of regenerative

agriculture was analysed by examining different ways in which it is defined and classified. The level of dissemination of the term “regenerative agriculture” in the literature of the subject and in research, and its popularity in society, was explored through a bibliometric and webometric analysis. The attitudes and practical approaches to regenerative agriculture were investigated on the example of the operations of four large agricultural companies and on the basis of the results of a project called “Biologisation: The Key to Sustainable Agriculture” in which the aforementioned businesses were involved alongside representatives of various organisations (a university, a scientific institute, a nongovernmental organisation, agricultural advisory centres, providers of services to agriculture, food industry businesses, a farmers’ trade association) as well as farmers. The aim of this project, which was implemented in 2020–2022 in the Erasmus+ programme for the education and training sector (Action 2, Strategic Partnership) financed by the Foundation for the Development of the Education System (Erasmus+ National Agency), was to build a lasting partnership for raising awareness by improving the vocational education of people working in agriculture.

The purpose of the article was to recognise how and to what extent the analysed concepts and practices of regenerative agriculture meet the principles of sustainable food production. We define sustainable food production as a paradigm of development that makes it feasible to balance social, economic and environmental concerns. The paper comprises five parts, starting with a description of the methods and data sources. The next paragraph provides an overview of the literature related to the definition and the theoretical and empirical sources of regenerative agriculture. The bibliometric and webometric analysis in section two of the paper was performed to show how the concept of regenerative agriculture has been disseminated in the space of scientific research and in social reception (the Internet). The analysis of qualitative and quantitative data presented in the next part of the paper serves to show the existing attitudes towards regenerative agriculture and the different ways it is implemented in agricultural practice in Poland, Czechia and Slovakia, based on the example of four large farms. The paper ends with a discussion and conclusions.

The term “regenerative agriculture” is ambiguous. There is no comprehensively, universally accepted and clear definition in the scientific and specialist literature [32]. Nor is there any strictly expressed difference between regenerative agriculture and other alternative agricultural production systems such as organic, sustainable agriculture; biodynamic agriculture; carbon agriculture; or agroecology [33,34]. Moreover, the concept of regenerative agriculture is applied to various entities and levels of aggregation, from a single farm to the entire food system [32]. For example, Robert Rodale, considered one of the creators of the regenerative agriculture concept, described it as agriculture “that, at increasing levels of productivity, increases our land and soil biological production base. It has a high level of built-in economic and biological stability. It has minimal to no impact on the environment beyond the farm or field boundaries. It produces foodstuffs free from biocides. It provides for the productive contribution of increasingly large numbers of people during a transition to minimal reliance on non-renewable resources” [34].

When defining regenerative agriculture, and the biologisation of agriculture, particular attention is paid to its function (i.e., purpose or result) in creating positive effects from agricultural operations. In particular, these include improved soil health, increased biodiversity, and the binding of carbon from the atmosphere [33]. In one example, the literature describes regenerative agriculture as “a system of principles and practices that generates agricultural products, sequesters carbon, and enhances biodiversity at the farm scale” [17]. Other general ways of understanding regenerative agriculture perceive it as practices or processes aimed at increasing biodiversity, enriching the soil, improving the condition of water resources, and strengthening ecosystem services by minimising outlays from outside the farm and limiting the negative external effects stemming from the farm’s operations [33].

The literature also offers definitions of regenerative agriculture based on approaches in which the explanations emphasise not only the effects but also the processes involved [33].

In this context, when trying to define regenerative agriculture, it must be said that a fundamental role is played by the actions that make up this model of agriculture and are aimed at achieving the desired state of a given system. In such an approach, agriculture is considered a set of specific agricultural practices. Depending on the semantic reach being considered, the aforementioned system might be the soil, a particular crop, an agroecosystem or even the whole natural environment. In the literature, such actions, which are usually defined as the methods, practices or principles of regenerative agriculture, include actions such as growing cover crops; using compost, manure and biopreparations; appropriate crop rotation; applying phyto-melioration; using certain simplified cultivation techniques (e.g., no-till, strip and bed farming), conservation farming, or soil mulching; growing papilionaceous/leguminous plants; implementing agroforestry practices or the proper choice of crop varieties (high-yield crops, agrophage-resistant crops); and combining crop production with appropriately managed animal breeding [8,15,21]. In this context, the examples mentioned include farm-managed natural regeneration that is pursued in connection with restoring soils for agricultural and agroforestry cultivation, particularly in countries with a deficit of arable land and problems with satisfying their population's food needs [35].

As the overview of existing literature shows, the actions that make up regenerative agriculture have largely been drawn from the guidelines previously developed under other systems of agricultural production, including integrated agriculture, ecological/organic farming, conservation agriculture, permaculture and precision farming [36]. A few key agricultural practices important for the aforementioned farming types are usually mentioned in the context of regenerative agriculture, such as limiting or avoiding ploughing, avoiding leaving the soil uncovered over the winter, increasing crop diversity, supporting water percolation into the soil, and combining crop and animal production on farms [17]. The regenerative agriculture (biological agriculture) trend emerged as an alternative to conventional (industrial) agricultural systems. Its beginnings were in the 1950s and 1960s [36]. At that time, this kind of approach to farming started developing within the idea of organic farming in a broad sense [37,38]. There is no question that regenerative agriculture also grew from the principles of biodynamic agriculture (in the 1920s and the Rudolf Steiner school) and what was known as natural farming, emphasising a concern for the soil and focusing on the quality of crops by engaging in specific measures such as stimulating soil organisms, preventing soil acidification, composting manure, choosing no-till farming, and using organic waste and natural preparations [37,38]. With the development of agricultural and biological sciences, some of the natural agriculture guidelines were expanded to include new findings that provided a scientific foundation for such systems. This process served to popularise systems known as organic-biological, biological, and ecological farming [39].

The scientific grounds for agricultural systems other than industrial, and the relevant practices, were formulated within agroecology (its framework also includes the concept of biological farming, among other things), which emphasises the development of agroecosystems based on the minimised use of chemicals and non-renewable energy and recommends taking advantage of the interactions and synergies between the biological elements of agriculture [40,41]. The principles of agroecology invoke traditional agricultural knowledge as well as the achievements of scientific research and the uniqueness of specific local conditions, which are particularly important for small-scale farmers all over the world. Agroecology guidelines may also be useful to operators of high-production farms, especially in the process of reorientation towards environmentally sustainable agriculture [40]. The common feature of all of the aforementioned agricultural systems that cite ecology and the laws of nature is the organisation of agricultural operations, in which the soil (and in particular the biological life within it) plays a fundamental role, while the general objective is to satisfy food needs with quality produce [37,38]. As Giller and associates [34] have stated, the concept of regenerative agriculture as it is most often understood today, and which corresponds to the biologisation of agriculture that is being promoted in Poland,

Czechia, Slovakia and other Eastern European countries, first emerged in the late 1970s and early 1980s in the United States, thanks to the research and publications of the Rodale Institute, Richard Harwood, and the proposals put forward by the activist and teacher Medard Gabel, as well as the increasing popularity of conservation farming practices [36,42]. At first, this idea was meant to make food systems relatively more sustainable and independent of external resources. This, in particular, concerned agriculture in “Third World” countries, where—in the long term—the development of food production based on energy from fossil fuels and advanced technologies did not take into account any environmental challenges or local economic, social and political factors affecting small-scale family farming [42]. At the time, one of the Rodale Institute’s directors, the agronomist Richard Harwood, outlined the rudiments of the philosophy of regenerative agriculture in 10 points [34]. According to Harwood, by using regenerative technologies (e.g., binding carbon dioxide by growing legumes, no-till farming, growing cover crops, leaving post-harvest residues, using organic fertilisers, crop rotation, and integrated crop protection) farmers could produce harvests comparable to those obtained at conventional farms but at significantly lower production costs [42]. This approach required the substitution of conventional means in agricultural production with the appropriate knowledge and new information, and also the use of the farmer’s own labour (and that of family members), which could help small- and medium-sized farms gain a competitive edge over large intensive-production farm companies [42]. Consequently, as Harwood believed, the farmers and their families could achieve a higher level of self-reliance and improve their income and food security.

However, the interest shown in regenerative agriculture in scientific, expert and public debates decreased noticeably in the early 2000s, which was connected with the spread of concepts such as sustainable agriculture, organic agriculture and agroecology [34]. The return of regenerative agriculture’s popularity in scientific literature, on the Internet, in traditional media and in farming practice was first observed in 2015–2016. This trend is believed to stem mainly from the adaptation of this concept by international nongovernmental organisations (Greenpeace, World Wildlife Fund, The Nature Conservancy, Friends of the Earth), transnational corporations (Danone, Kellogg’s, General Mills, Unilever) and charity organisations [34]. The popularity of regenerative agriculture as a concept led to this system of agricultural production being subjected to certification. In 2017, the United States saw the launch of the Regenerative Organic Certified (ROC) programme managed by the Regenerative Organic Alliance, which includes the Rodale Institute [34]. The certification of agricultural production in the ROC system is spread over several years, varies depending on the initial situation on a given farm, and consists of three pillars and three levels related to healthy soil, animal welfare and social fairness. At successive stages of ROC certification, farms may take advantage of other existing certification systems (concerning ecological production, animal welfare and social responsibility). The Centre for Regenerative Agriculture and Resilient Systems at California State University, Chico, offers a programme of studies in regenerative agriculture as well as a research and advisory unit conducting research in this area. The growing popularity of regenerative agriculture in various forums and areas of business has led to this trend being acknowledged as one of the most influential among the currently emerging alternatives to the productivity- and industry-focused discourse in agriculture [43]. On the other hand, this concept has started to be widely used and promoted by large, industrial agri-food companies in order to implement their business strategy of presenting themselves as consumer-, environment- and climate-friendly food producers.

2. Materials and Methods

The study involved a variety of research methods and a number of sources of data and information (Figure 1). In order to reach the research objective, the first step was to analyse the current literature on regenerative agriculture (stage one presented in the Section 1). The theoretical outline was mainly based on scientific literature, expert publications and reports related to the various ways of understanding of this concept, as well as its scientific

background and stages of development. The methods used include desk research analysis and content analysis.

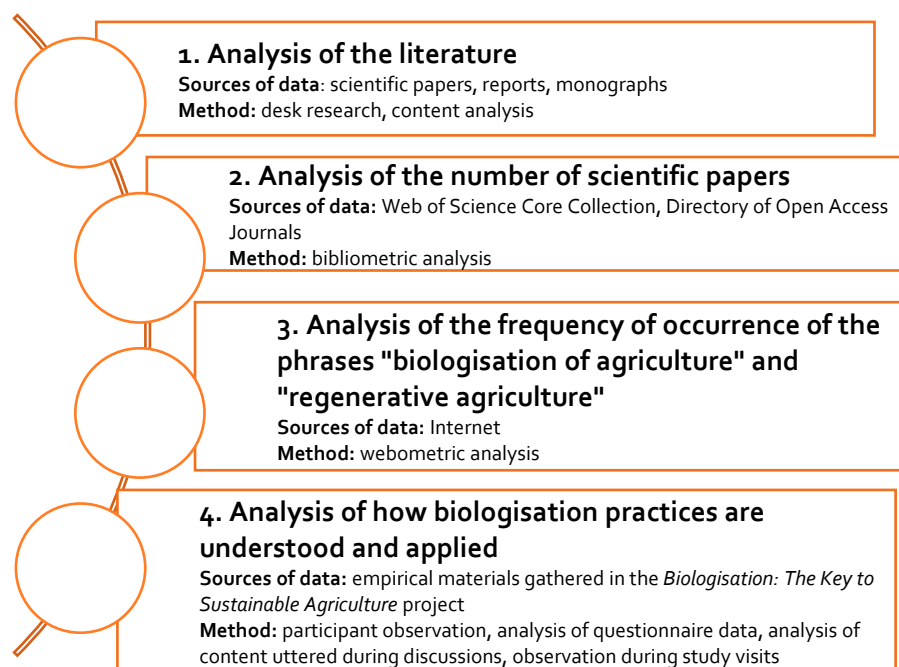


Figure 1. Methodological approach used to study the concept of regenerative agriculture.

Secondly, in stage two, in order to identify the place (extent of dissemination) of the regenerative agriculture concept within the space of scientific research and among society (the Internet); in particular, material gathered in international databases of scientific and popular science articles were used. The conclusions reached with the help of these information resources were formulated mainly with the help of quantitative analysis (webometric and bibliometric analysis). The analysis of scientific and popular science databases took into consideration the number of articles in the leading international databases of this kind (i.e., the Web of Science Core Collection (WoS) and the Directory of Open Access Journals (DOAJ)).

For the purpose of the study concerning the recognition of the “social reception” of regenerative agriculture, the Internet was also used (stage three). The frequency of occurrence of English phrases and keywords such as “biologisation of agriculture” and “regenerative agriculture” using the Google Trends and WordItOut (online version available since 2010) tools (Figure 1) were included. The observation time range for both the Internet and the databases of scientific achievements comprised various periods over the years 2000–2022.

Lastly, in stage four, the different approaches to the guidelines and practices of regenerative agriculture in Central and Eastern Europe countries were additionally characterised on the basis of empirical material gathered in the “Biologisation: The Key to Sustainable Agriculture” project (Figure 1). Quantitative and qualitative information and data were collected from the partners of this project and from its participants in the years 2020–2022. The project partners were four equity-related large farms located in Poland (two companies), Czechia (one) and Slovakia (one) as well as a university and a scientific institute specialising in the economics of agriculture and rural studies. The other participants in the project, who took part in workshops, meetings and discussions, included self-employed farmers and students of university-level agricultural courses, representatives of a nongovernmental organisation, employees of agricultural advisory centres, providers of services to agriculture and food industry businesses, and a representative of a farmers’ trade association. The data and information for the study were gathered using various research methods

and techniques, including surveys (questionnaires related to the project and gathered from 53 unique respondents during four international meetings at the farms in Poland (two meetings), Czechia (one) and Slovakia (one)), observations of regenerative agriculture practices/biologisation practices on-site at the farms during four study visits, and an analysis of materials in the form of statements gathered during six meetings and discussions of the project participants.

3. Results

Organic agriculture, sustainable agriculture and agroecology have been familiar concepts and widely analysed in the scientific literature for a long time. They are also concepts that are increasingly appearing in public and social debates. By comparison, issues related to regenerative agriculture are relatively less well-known or analysed, especially in Eastern Europe [17]. This is demonstrated by the small volume of papers on regenerative agriculture and biologisation of agriculture in the leading international scientific journal databases. In the years 2000–2021, the WoS database recorded 1374 papers containing the phrase “regenerative agriculture”, while the DOAJ database recorded 143. It needs adding that this expression was found in the publication titles in just 42 and 7 cases, respectively (Tables 1 and 2), which means that regenerative agriculture was usually not the main object of the research described in these texts. Nevertheless, it is worth noting that scientists’ interest in regenerative agriculture has been growing noticeably in recent years (Figure 2). By comparison, the number of scientific papers in the WoS database that contain the phrases “biologisation of agriculture” or “biologisation of farming” stood at just 14 and 9, respectively (Table 1). In another well-known international source, the DOAJ database of open-access scientific achievements, the number of papers containing these two phrases was even lower, at five and two, respectively (Table 2).

Table 1. Frequency of occurrence of selected key phrases in the Web of Science Core Collection database, 2000–2021, global data.

Element of the Resource (Publication)	Key Phrases		
	“Biologisation of Agriculture”	“Regenerative Agriculture”	“Biologisation of Farming”
Subject	13	223	15
Title	5	42	4
Open access	15	754	9
Paper	14	1374	9
All fields	26	1667	16

Table 2. Frequency of occurrence of selected key phrases in the DOAJ database, 2000–2021, global data.

Element of the Resource (Publication)	Key Phrases		
	“Biologisation of Agriculture”	“Regenerative Agriculture”	“Biologisation of Farming”
Title	5	7	2
Abstract	26	70	10
Keywords	3	30	0
All fields	30	148	11

The data presented in Table 2 show that the volume of publications in the DOAJ database containing the phrases “biologisation of agriculture” and “regenerative agriculture” was relatively small. In addition, there were over five times more scientific papers related to “regenerative agriculture” than those using the phrase “biologisation of agriculture” (148 versus 30). In both cases, these expressions appeared more often in the abstracts of papers and much less often in the titles (Table 2).

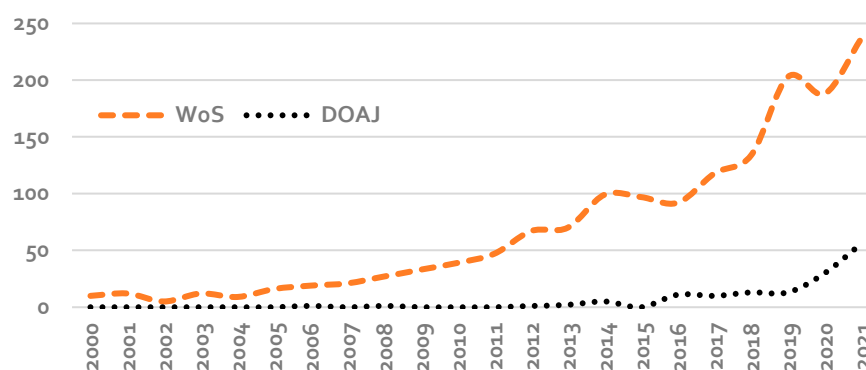


Figure 2. Frequency of occurrence of scientific papers containing the phrase “regenerative agriculture” in the Web of Science Core Collection and Directory of Open Access Journals databases, global data.

On the Internet, the set of Google searches conducted in Polish in January 2022 contained very few occurrences of the key phrases “*biologizacja rolnictwa*” (biologisation of agriculture) and “*rolnictwo regeneracyjne*” (regenerative agriculture), which were additionally used in a narrow sense. The key phrase “*biologizacja rolnictwa*” most often appeared in searches asking about biodynamic plant cultivation, biodynamic farming as such, and biostimulators in agriculture. “*Rolnictwo regeneracyjne*” was mentioned in the context of searches concerning this approach to agriculture in Poland, biodynamic farming, and regenerative farms. The insufficient number of searches related to the above two key phrases ruled out an analysis of the trend using automated web monitoring tools such as Google Trends.

An analysis of the Internet in English showed that the term “regenerative agriculture” generated moderate interest from web users (but much greater than the term “biologisation of agriculture”). The former term garnered interest from users in various regions, but most often in New Zealand and Australia and less often in South Africa, Canada and Ireland. The relatively fewer Google searches by Internet users from European countries is noticeable. An analysis of the Internet using the Google search engine and the WordItOut (Enideo) tool also documented the contexts in which users of the English-language web searched for information related to the term “regenerative agriculture”. Searches involving the phrase in question were mainly related to human activity in crop growing and animal breeding (farming/agriculture, ecological agriculture, permaculture, cultivation, agroecology), and much less often to specific geographical locations (Australia, New Zealand), phenomena widely discussed around the world, threats and challenges (climate, climate change, sustainability), or resources and elements found on the planet (soil, carbon). There was also a noticeable volume of searches on regenerative agriculture in the context of obtaining know-how, as suggested by web user questions about training courses and podcasts.

Figure 3 shows the frequency of occurrence of the key phrase “regenerative agriculture” in the years 2010–2021 all over the world, based on the Google Trends tool. The numbers reflect the frequency of searches in relation to the highest point on the graph. A value of 100 indicates the term’s greatest popularity in the given period. A value of 50 signifies half of the maximum interest shown in the term. A value of 0 means no data on the given term.

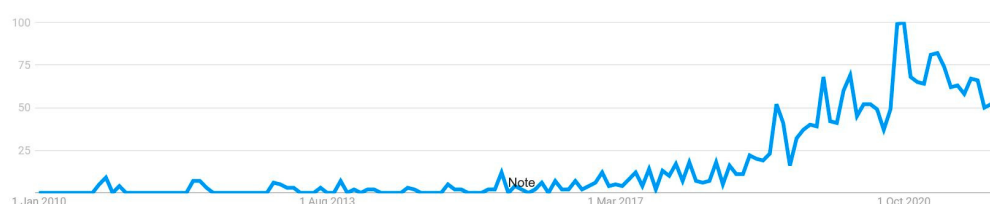


Figure 3. Frequency of occurrence of the term “regenerative agriculture” in Google searches in the years 2010–2021, global data.

The popularity of the term “regenerative agriculture” was negligible over the period under consideration. This is especially true of the years 2010–2016 (Figure 3). After that (around 2017), the term’s popularity among Internet users around the world rose slightly, and increased dynamically over 2018 and 2019. The greatest volume of searches involving the phrase “regenerative agriculture” was recorded in 2020. This might be linked to the outbreak of the COVID-19 pandemic, which caused significant turmoil in the functioning of food supply chains and led to food consumers and producers paying more attention to the health aspects of foodstuffs being produced and eaten. Another reason for the growing popularity of regenerative agriculture was that this concept was incorporated into the strategies and actions of international and recognised business and social organisations [34,43].

As the results of the bibliometric and webometric analysis show, regenerative agriculture has not been widely present in scientific research or in the Internet space so far, nor has this concept been particularly familiar to farmers. For example, the results of a survey among 595 farmers running farms of at least 10 hectares conducted in Poland in 2022 showed that knowledge on regenerative agriculture and the availability of information on the subject was modest. More than a third of the respondents did not know what regenerative agriculture was, and more than half of them said that the availability of information about it was poor [23]. In-depth knowledge on the perception and attempted implementation of the regenerative agriculture model and practices in East-Central European countries was gained in the course of the Biologisation. . . project [22]. This project included an analysis of attitudes towards this model of agricultural production among the employees of four large agricultural companies at which the model in question was already familiar and had been implemented for a number of years; it also analysed the opinions of various experts and other participants of this initiative.

At the agricultural companies in question, which are located in Poland, Czechia and Slovakia, the terms “biologisation of agriculture” and “regenerative agriculture” were used interchangeably and defined as “agrotechnology improving the condition and ‘health’ of the soil, which. . . comprises methods and actions that improve the soil’s condition, increase its fertility through the increase of organic matter (humus), actions that serve biodiversity, efforts to balance out soil components, and the choice of appropriate practices and means for production—reducing the amount of synthetic agents to a minimum in favour of natural ones” [44]. Putting the idea of regenerative agriculture into practice at the aforementioned companies began in the second decade of this century. As a result, moving forward by trial and error, the companies developed a set of practices supporting biologisation. These mainly included the following: in-depth analyses of the soil, regulating the proper level of calcium in the soil, regulating the proper level of microelements in the soil, increasing the amount of organic matter and carbon in the soil, increasing crop diversity through extensive crop rotation and cover crops, limiting soil cultivation, applying precision farming practices and looking after the socio-cultural environment. These practices together served to form an original code of agricultural practices (the “5C Code”, its name coming from the first letters of the English words describing the practices: calcium, carbon, cover crops, cultivation and culture) that were followed in the companies’ agricultural operations and, with time, popularised in the public, expert and market space [22,44]. When asked about how important biologisation was for agriculture’s sustainability (economic, environmental and social), the project’s participants most often mentioned all three of these sustainability aspects. Thus, this model of agriculture was perceived comprehensively as a way of increasing the overall sustainability of agriculture.

According to the employees of the companies in the study, adopting and following the practices of regenerative agriculture was a response to the growing climate, environmental and financial changes that these businesses faced. The knowledge needed to develop their original concept of regenerative agriculture, i.e., the biologisation of agriculture, implemented on the basis of the 5C Code, was drawn from the precursors of the regenerative agriculture concept proposed by Gary Zimmer and David Brand from the United States.

The employees recounted that these biologisation experts and practitioners had pointed out the importance and necessity of introducing “natural”, environment-friendly production methods that had been used and proven in the past, before industrial farming had begun to spread. Due to geographical differences between Poland, Czechia and Slovakia and the United States, and due to the need to learn and test a wide range of know-how and practices involved in regenerative agriculture, adapting this idea to the way agriculture is run in the Eastern European region took place in stages. This is how a manager at one of the companies in Poland (Wielkopolskie province) described the process:

First and foremost, we introduced biological production methods. Meaning we went back to our roots. A little ineptly at first, groping around, we started looking over the ocean, observing the Americans, as they were the ones to launch all those measures connected with regenerative agriculture quite early on.

As employees from the company in Dolnośląskie province, Poland, underlined, agricultural production according to the requirements of biologisation was a useful tool for achieving financial equilibrium. This is especially important in a situation of rapidly growing costs for agricultural production such as energy and nitrogen fertilisers, which went up by up to a few dozen percent in the past season. Biologisation through reduced use of such means enabled substantial savings to be made. Other motives for switching the company towards regenerative agriculture included the complex and changeable external conditions.

We are also motivated to change our agriculture actively, since this whole environment is rather restricting our food production technology options, so we have to keep thinking ahead, about the future, how to handle production so as to maintain the level of productivity and [yield] per hectare at the same level.

According to the company’s employee, regenerative agriculture was and is not only a way for the company to adjust to the expectations of society (consumers), business partners and political institutions, but also a way of presenting the company’s operations to its environment. This is how a representative of one of the Polish companies presented the reasons why biological/regenerative farming practices had been initiated:

Biologisation and thinking sustainably may help avoid a multitude of problems. And we must be the first to be such farmers, who show that we use this biologisation, who show that our products [are] made in a sustainable fashion, in the proper way, in a natural way. . . . And [that] we look after the landscape, the soil, nature much better than the media show us doing.

The motivation of the Czech company’s employees to follow the regenerative agriculture model was similar. In the most general terms, they understood biologisation, knowledge about which they described as being poor among Czech specialists and society (the conventional system of agricultural production predominates), as striving to be the best possible farmer. In practice, this meant changing the predominant way of thinking about agriculture and implementing the new approach. However, according to a Czech participant in the “Biologisation. . .” project who was responsible for crop production as well as research and development at their company, regenerative agriculture is a new concept based on well-known practices. He claimed that, today, the greatest challenge for all agricultural producers was adjusting to climate change, which has a strong impact on soil. That is why this person thinks the focus should be on reducing the negative impact of operations on the climate. In the Czech company, major elements in the transition to the regenerative agriculture system included protecting the soil through avoiding its compaction by limiting and controlling the movement of machinery in the fields (controlled traffic farming), ensuring crop diversity, proper selection of crops for cultivation (especially species with an extensive root system) and incorporating animal production into farm operations.

In the case of the agricultural company in Slovakia, its representatives said that pesticides and mineral fertilisers were used in excessive amounts, unprofessionally and too

often. The soil is often sown wrong as well. Due to reduced animal production operations and an increase in monocultures, organic matter was decreasing in arable land. For these reasons, the company in Slovakia began using a new approach to the soil. Since then, they have worked to make sure the land in use is in good condition, and believe that the most important regenerative agriculture practices include cover crops and precision farming solutions, especially the use of satellites, drones, computer software as well as the spraying maps developed on this basis. This approach enables crop spraying to be carried out with great precision, thanks to which, the farm in question reduced the amount of weed killer it used by about 25%.

The main aim of these applications is to economise by using smaller amounts of pesticides and mineral and natural fertilisers. These tools enable us to have a positive impact on the farm's profits, thanks to the selective use of herbicides, where only weeds and not crops are sprayed.

Although the employees at the companies in the study had followed a variety of regenerative agriculture practices for several years, their knowledge on the subject was inadequate. The diversity of local conditions for conducting agricultural operations in the three countries, as well as the differences in the organisational cultures and the wide range of issues involved in the agricultural model under consideration, led the project participants to express a desire to expand their knowledge and exchange information. The great majority of them (alongside the four agricultural companies' employees, the participants included farmers, students, trainees, advisors and processing company workers) increased their knowledge about biologisation thanks to participation in the project. Among the project's 53 participants, 24 expanded their knowledge significantly and 21 expanded it very significantly.

In general terms, the employees of the companies from Poland, Czechia and Slovakia as well as the other project participants mentioned three reasons for their interest in regenerative agriculture (Figure 4). Regardless of a person's job or function in their company, the most frequent reason for joining in activities expanding their knowledge about the biologisation of agriculture was related to environmental and climate issues (concern for the environment and climate, concern for children, for future generations—36 people), professional reasons—32 people, as well as reasons connected with food consumer health (improving food quality—27 people, concern for children, future generations—25 people). In the group under consideration, taking part in the project and learning more about biologisation was also connected with individual reasons, i.e., a person's job situation—wanting to improve work results in the given agricultural company (increasing the scale of production, improving the profitability of operations). In total, 48 of the 53 participants described the knowledge they had gained about biologisation through taking part in the project as being useful in their work (38 people) or in their professional development (10 people).

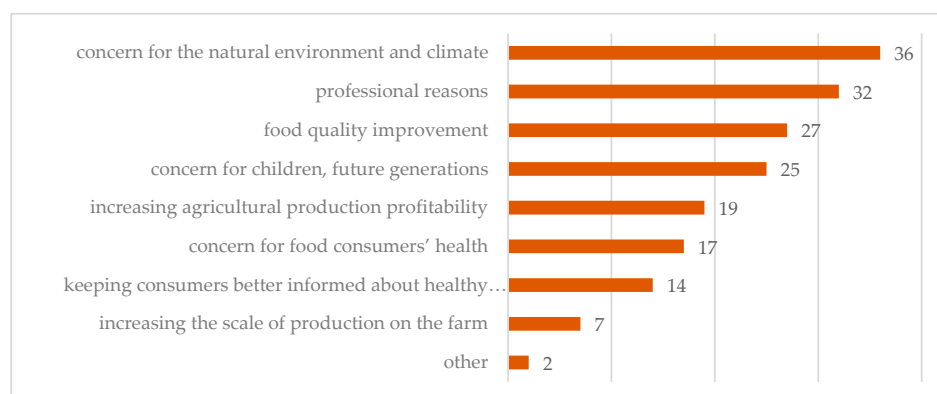


Figure 4. Reasons for the project participants' interest in biologisation methods in agriculture. Source: questionnaire survey (N = 53; the three most important reasons could be chosen).

4. Discussion

In order to maintain and increase agricultural production for food and non-market purposes in the long term, it is essential to take care of the sector's fundamental production component, namely soil [45]. Previous systems and practices in agriculture have contributed to the worsening of the condition of soil, regardless of the increased efficiency and scale of production. New agricultural systems and practices, including the practices of regenerative and biological farming [6,8,44], are now promising approaches to uphold the production function while respecting and renewing the soil and other environmental resources. Today, as indicated earlier in this text, biologisation and regenerative agriculture are still considered niche systems, having various definitions and being understood in various ways (also by practising farmers), and are poorly identified in scientific discourse and in the public space. This also applies to the agricultural sector and the societies of East-Central European countries (e.g., Poland, Czechia and Slovakia) [22,23]. There are several reasons for such a situation, including agricultural policies, the predominant approach to agricultural production, the existing system of knowledge and innovation transfer in agriculture, and the adopted ways of adjusting to climate change [46]. However, such undertakings are increasing in popularity all the time [10,17,47]. One of the reasons why regenerative agricultural practices are garnering interest is the fact that they are based on a holistic approach to the food system, combining modern and traditional knowledge (micro-biology, agrobiological intensification, precision farming), which leads to changes in the organisation of agricultural production, technological and process innovations, and the widespread use of renewable energy (e.g., wind, solar energy) [10].

The concepts of regenerative agriculture and biologisation define the direction of changes in large-scale and industrial farming. By following appropriate practices that fulfil the strict requirements of environment- and climate-friendliness, even agricultural operations on a large scale, using digital technologies and advanced farming machinery and devices, can limit their negative external impact and generate positive effects for the natural and social environment. Some studies involving farmers indicate a relatively higher level of awareness of agricultural production's negative impact on the natural environment among operators of farms with, on average, greater economic potential, greater production intensity and better economic results [48]. The results also confirm the practices and declarations observed during the research carried out in the "Biologisation: The Key to Sustainable Agriculture" project. Thanks to their economic potential, the use of advanced technologies and the know-how and skills of their employees, the large agricultural companies in Poland, Czechia and Slovakia were among the first businesses in their countries to implement, adapt and popularise regenerative farming practices [22]. With advanced precision farming solutions at their disposal, farms with substantial production potential are able to gather detailed data on the crop production environment that is variable over space and time (soil pH, amount of nutrients, moisture, organic matter content, crop diseases, weed proliferation), and adjust agrotechnical measures (precision fertilising, spray control, precision cultivation and sowing, mechanical weeding) accordingly [49]. For example, using variable rate application (VRA) of pesticides or fertilisers in crop production serves to achieve financial gains and social benefits [50].

Following the principles of regenerative and biological farming not only brings positive effects for the environment, it also enables relatively satisfactory production and economic results to be achieved. Obviously, the financial benefits gained from these practices depend on many factors: a farm's initial situation, market conditions or a farmer's choice of specific actions. In many cases, it is possible to maintain a crop yield comparable with or greater than that from conventional farming, and there are also chances for reducing production costs, especially the costs of energy, labour, fertilisers and plant protection products [17,51]. The profitability of production may also increase if broader economic calculations are taken into account (e.g., through biological benefits stemming from the storage of additional amounts of nitrogen, phosphorus and potassium in the soil after ploughing legumes in the field for subsequent crops, or through reduced pesticide

use) [52,53]. The profitability of regenerative agriculture practices also increases in the face of extreme or unfavourable agroclimatic conditions (e.g., high temperatures, water deficit), since they contribute to increased crop resilience and yield levels [54–56]. However, some regenerative agriculture systems do lead to relatively smaller yields and income or reduced animal production, especially in the short term [57]. In such cases, it may be possible to boost the likelihood of achieving profitability by increasing the agricultural producer's mark-up through participation in production quality certification systems [17].

The literature not only points to the benefits of following the principles of regenerative agriculture but also draws attention to a number of limitations and controversies. Such criticism has been offered from various viewpoints, including agronomy, economics of agriculture, history, political economics, and sociology [34,43]. One interesting fact has been pointed out by Giller and associates [34], namely that the concept of regenerative agriculture has recently won support from various groups functioning within the agricultural sector and the food system who often having contradicting interests. Indeed, the concept has been promoted not only by community and nongovernmental organisations (Rodale Institute—Kutztown, PA, USA, Project Drawdown—St. Paul, MN, USA) and universities (California State University—Chico, CA, USA), but also by large multinational agrifood corporations (Cargill—Minneapolis, MN, USA; Patagonia—Ventura, CA, USA, General Mills—Golden Valley, MN, USA). This trend is also confirmed, for example, by the aforementioned agricultural companies from Poland, Czechia and Slovakia, which are part of a multi-national agricultural business. With large-scale business operations, there is often a risk of conflict between market values on the one hand and social and environmental ones on the other, or that the latter may be used as a public relations strategy. The risk thus exists that large business entities might use the term “regenerative farming” chiefly as a buzzword and a marketing ploy, masking their pursuit of their own business or financial goals while pretending to practise corporate social or environmental responsibility [34]. The observations from the study involving farms in Poland, Czechia and Slovakia did not confirm those fears. The results of the survey conducted among the farms' employees and from on-site observations indicate a significant role of non-financial (postmaterialist) motivation in adopting the regenerative agriculture model and biologisation practices. Also, the regenerative agriculture promoted by many businesses usually comprises a diverse range of agricultural practices or practices connected with farming, as proved by the aforementioned case study on Polish, Czech and Slovak companies. It has been suggested that some businesses and farms may only highlight principles that are “convenient” from their point of view, and ignore the social, environmental and climate-related aspects of regenerative agriculture as well as aspects connected with processes of learning and developing appropriate actions on a local scale [43].

At the same time, there are many practices within regenerative agriculture that have long been considered beneficial from the point of view of production and the environment, such as crop rotation, leaving post-harvest residues in the field, combining crop production with animal production and sowing cover crops. It has been pointed out that some of them have been part of the code of “best farming practice” for quite some time and are a part of conventional farming [34]. Other measures perceived as belonging to regenerative agriculture may cause controversy or have limited impact. For example, conservation farming can be a part of operations based on GMOs, herbicides and artificial fertilisers. Permaculture is not usually implemented on a large scale and does not apply to a lot of agricultural produce. Moreover, it is believed that increasing the content of organic carbon in the soil by following practices recommended by re-generative agriculture improves the situation in the short term. According to some researchers, in the longer term and on a global scale, increasing harvests and maintaining soil fertility without fertilisers will be difficult [34]. The growth of agricultural plant and animal production for energy-generating purposes (energy crops, maize silage, manure, fruit and vegetable residues) may thus turn out to be problematic. The demand for biofuels or biogas can limit agricultural production for food [2]. At the same time, agricultural biofuel or biogas production can tend to be

intensive and cause the degradation of soils and water sources and reduce biodiversity [3]. One way to avoid conflict and achieve synergies between the food, environmental and energy functions of agricultural production is through regenerative agricultural production systems, called agro-ecological symbioses [5,6].

Doubts are also being voiced as to the assumption that anthropogenic carbon dioxide emissions can be eliminated by the propagation of regenerative agriculture practices, and that sufficient agricultural production levels can be maintained with limited use of plant protection products [34]. The regenerative agriculture catalogue also includes niche measures with ambiguous economic and environmental outcomes. For example, reducing the area under cultivation as the basis of regenerative farming is often combined with the use of herbicides, especially in the initial period of switching a farm to new, eco-friendly production methods [36].

Some authors suggest that regenerative agriculture practices (reduced ploughing or pesticide application) are often propagated in isolation from specific local agro-climatic and economic conditions, and without considering that they probably will not be beneficial in all contexts. For example, the principle of reducing fertiliser use is fine in rich countries, whereas in Africa it would have a negative impact [34]. That is why any activity undertaken within regenerative agriculture and combining a multitude of practices should be adjusted to local biophysical and social contexts [57,58].

Growing interest in regenerative agriculture, as was the case with the employees of the agricultural companies studied in Poland, Czechia and Slovakia, implies the reformulation and merging of concepts that were previously considered opposite approaches to the future of agriculture, namely sustainable agriculture/agroecology and intensification. The debate over the direction agriculture should take may thus become muddled, drawing attention away from the important production and climate challenges that the agrifood sector faces [34,58]. There are also voices that wide interest in regenerative agriculture without a precise definition and proper understanding of the concept by various groups and businesses could contribute to poorer implementation of its significant guidelines [34]. The lack of a cohesive and widely accepted understanding of regenerative agriculture could also lead to a lack of public trust in businesses using and following the rules of this system of production [33].

5. Conclusions

Based on a literature review as well as quantitative and qualitative analyses of primary data, the authors aim to analyse various ways in which regenerative agriculture is defined, understood and implemented, with Poland, Czechia and Slovakia serving as examples. An examination of the literature shows that regenerative agriculture is a relatively new and diversely described concept drawing on many models of agriculture. The results of a bibliometric and webometric analysis suggest that the scientific, expert and public perception of regenerative agriculture is still limited. In the countries under consideration (Poland, Czechia and Slovakia), regenerative agriculture is often identified with the concept of biological farming (biologisation of agriculture), and the conscious implementation of its practices at farms is infrequent, usually only taking place at large farms.

The regenerative farming trend originated from the concepts of natural, biodynamic and organic agriculture as well as agroecology, which developed in the 20th century. It is thus a new idea that largely invokes older and well-tested methods of crop production and animal breeding, highlighting the need to rebuild and strengthen the potential of natural production resources in agriculture, and to undertake actions serving to regenerate agricultural systems. Regenerative agriculture is usually understood to mean agricultural production based on “natural” methods and tied closely to mechanisms occurring in nature. Its fundamental purpose is usually believed to be to produce healthy food and protect the environment. The literature analysed in this study was dominated by definitions of regenerative agriculture that placed an emphasis on the process (methods, principles of regenerative agriculture) involved in this approach to growing crops and breeding animals

or accentuated the effects (goals) of this form of agriculture (environmental protection, production of healthy foods). In other words, regenerative agriculture may be described as a set of agrotechnical measures whose main goal and object is the soil. Regardless of how the issue of regenerative agriculture is making a presence in science and farming practice, it needs saying that no comprehensive and cohesive definition of the term has been developed yet. Nor are there any unified ways of measuring and studying regenerative agriculture, or any widely adopted indicators. The conclusion is that it is a concept still at the formation and operationalisation stage.

On the basis of the materials analysed here, we can say that the expression “biologisation of agriculture” is very close in meaning to the term “regenerative agriculture”. The former term was more strongly present in the Polish, Czech and Slovak scientific and public space, while the latter was more prominent in scientific research and in the public debate mainly in English-speaking countries. The growing popularity of regenerative agriculture should be ascribed to the increasing world trend towards the sustainability of food systems in terms of production, environmental and social considerations. Future research should analyse the importance of regenerative agriculture practices in reducing the costs of agricultural operations, including energy costs, and also the importance of this system from the point of view of agriculture’s role in producing food and renewable energy. It would also be advisable to devote more attention to and support interdisciplinary research on the biologisation of agriculture and on regenerative agriculture, including studies on the economic, environmental and social factors as well as the effects of the practices involved.

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