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Global and national conditions of the sustainable development of agriculture.

Economic assessment of external effects and public goods in agriculture.

Sustainable agriculture and food security.

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CHAPTER II

NON-INDUSTRIAL SUSTAINABLE INTENSIFICATION OF AGRICULTURE

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

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

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

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

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

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

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

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

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

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

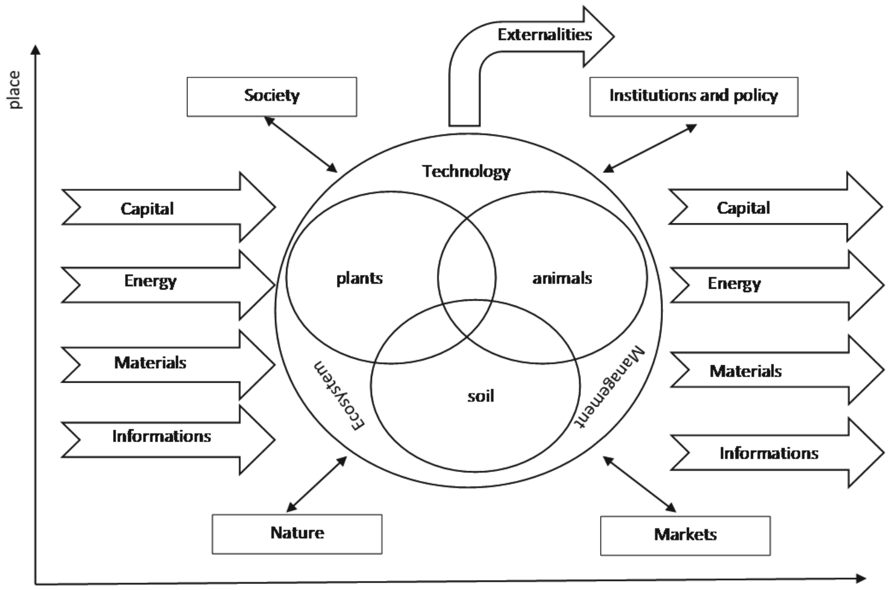
Given the ontological primacy of nature in the revolutionary changes in agriculture paradigms as part of the third green revolution, the starting point for an epistemological analysis of non-industrial sustainable intensification of agriculture is the systemic nature of the environment. As Larry Phelan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

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

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

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

Figure II.1. Holistic aspect of agroecosystem



Source: own study based on [Caporali 2010].

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

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

BOX 1. THE CONCEPT OF THE PLANT HOLOBIONT

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

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

continued BOX 1.

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

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

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

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

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

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

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

2. Types of non-industrial intensification of agriculture

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

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

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

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

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

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

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

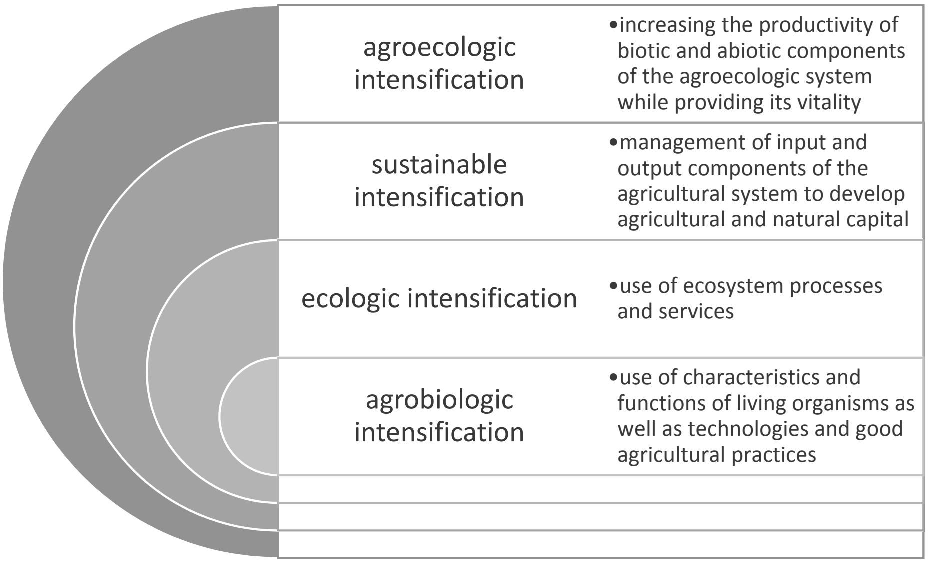
continued Table II.1

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

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

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

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



Source: own study.

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

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

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

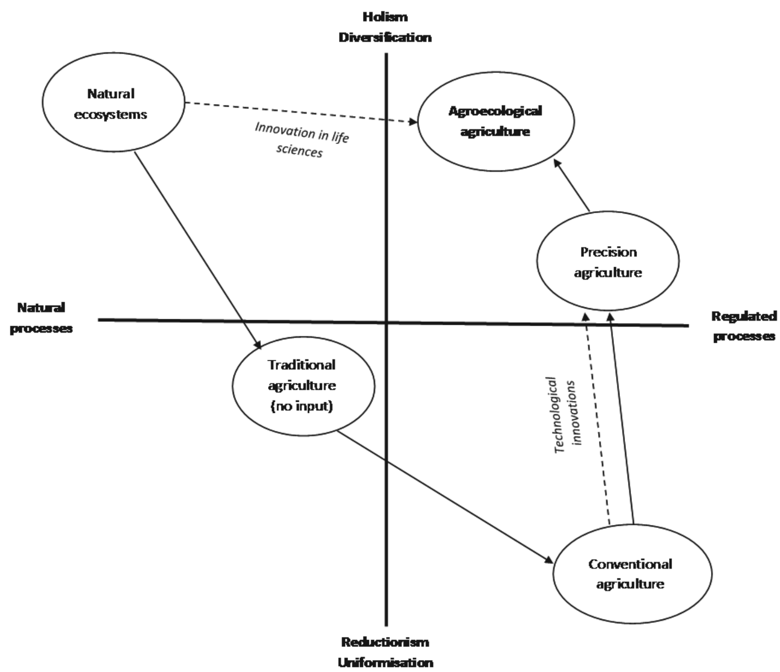
3. Differences between the non-industrial sustainable intensification of agriculture and alternative intensifications

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

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

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

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



Source: own study based on [Griffon 2013].

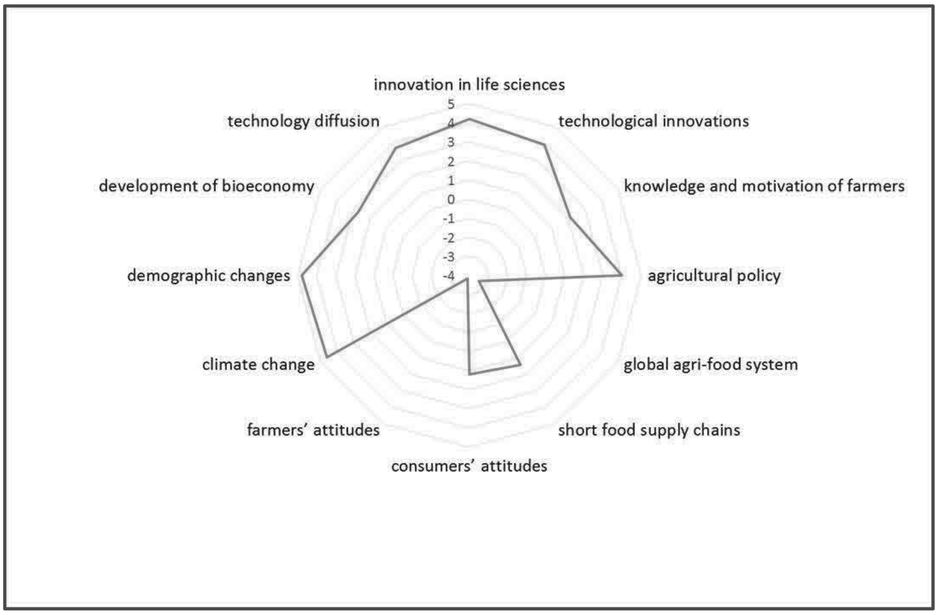
In view of the above, we can support the opinion by Jacqueline Loos et al. [2014] who claim that the current use of the term "sustainable intensification" can be potentially misleading as it inadequately refers to the main principles of the sustainable development. They highlight the critical shortcomings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

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

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

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

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



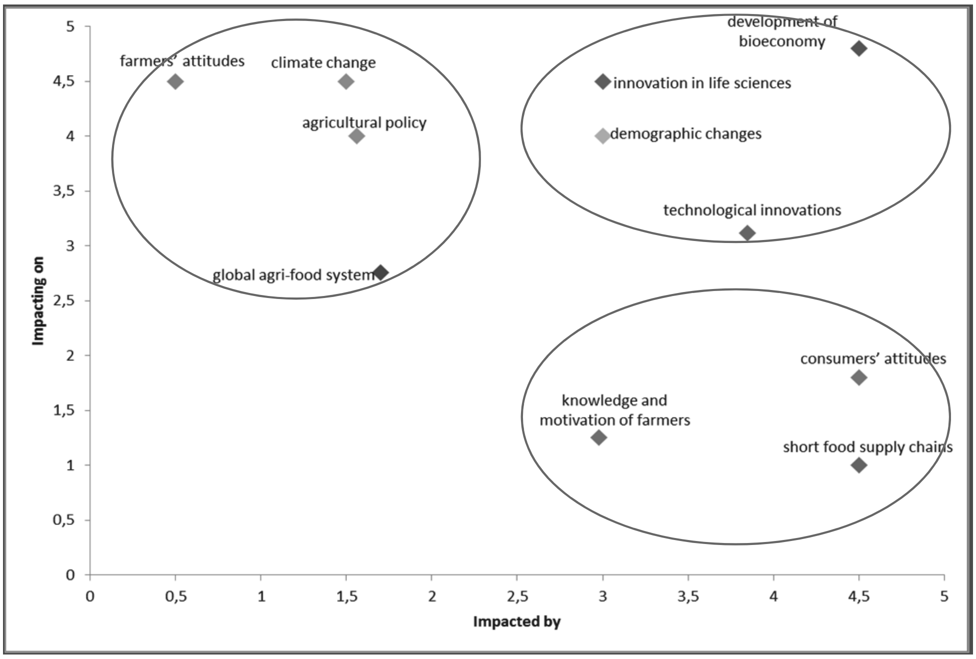
Source: own study based on the foresight study.

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

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

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

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



Source: own study based on the foresight study.

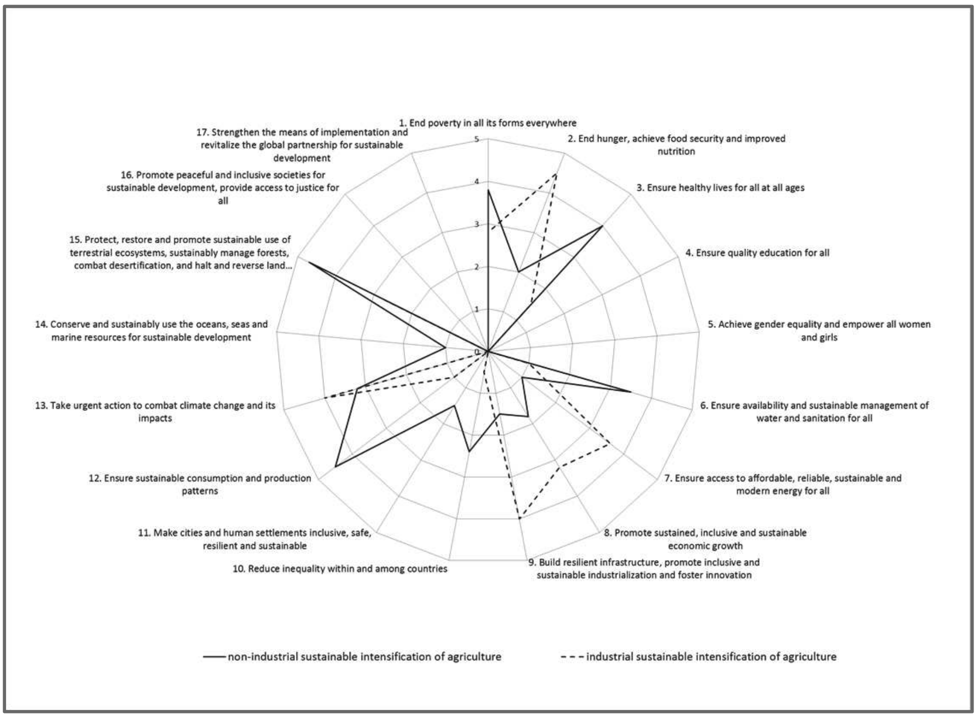
Three groups of factors have been identified based on the experts' indications. The first group brings together factors with a high impact potential, which, at the same time, are not much susceptible to impact. They include climate change, demographic changes, global agri-food system and agricultural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

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

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

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

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



Source: own study based on the foresight study.

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

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

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

Source: own study.

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

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

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

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

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

The redirection of the path of the agricultural development rises also many questions, answers to which seem to be a pre-condition for implementation of real solutions and visible changes. There are a lot of questions to be answered. From the narrow – production perspective there is a big question about how to balance the production factors engagement in the agroecological system and what will be

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

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CHAPTER II: NON-INDUSTRIAL SUSTAINABLE INTENSIFICATION OF AGRICULTURE

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