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RESEARCH ARTICLE

Towards climate smart agriculture: How does innovation meet sustainability?

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Abstract

A sustainable future is our task. All participants of the economy – including the farmers, food industry, retailers, and consumers – must give appropriate answers to the changes that fit and serve the sustainable world. To inherit a livable world for the future, we need to find and adapt those farming activities, solutions, and technologies that are suitable for effective production, ensuring viability, and adapting to climate change, too. Questions of food safety, food traceability, environmental pollution, or the increasing food demand have been discussed from several aspects by agricultural economists. In this paper, we highlight the role of precision farming as an innovation in agriculture as a way of getting closer to Climate Smart Agriculture (CSA), and the role of innovation in agricultural development in the context of the paradigm of 'de-growth'.

The new values (Réévaluer – reappraise) suggest the intent of preserving nature, at least in the current condition. CSA (including Precision Agriculture) is a tool in this and allows the efficient use of natural resources (Restructurer – restructuring factors of production). Each farming strategy in which the farmers' cooperation is the base of an efficient machinery use (Restructurer – restructuring of social relationships), each technology that reduces the human-health risk (Réduire – reduction) shows into the direction of 'de-growth' or other words: into the direction of sustainable development.

We believe that it will not be possible to maintain a sustainable economy without strengthening the rural areas, helping farmers to find successful ways/strategies for being competitive, innovative, and to cooperate with each other.

Keywords – efficiency, Agriculture 4.0, precision agriculture, innovation diffusion, 'de-growth' theory

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INTRODUCTION

A sustainable world is today's generation's responsibility. Due to the constant changes in agriculture – i.e., climate change to face with, technical development, Agriculture 4.0, etc. – those solutions should be analyzed and adapted that help to reduce the effect of limitation of resources, environmental burden and make the rural territory livable. All participants of the agricultural production chain must find the optimal solution and strategy concerning the main principles of sustainability (Chilinsky et al., 1998; van Wijk et al., 2020).

The aim of this paper is to create the connection between sustainable agriculture to CSA through the concept of innovation diffusion. It will be based on the example of precision farming (PA) reaching far from the new economic theory – the 'de-growth theory.' Based on the literature and on our own former research results, a content analysis was carried out, and logical modeling was used to apply the theory to agriculture. Thus, the paper begins by discussing the topic of sustainability in agriculture. The dispersion of PA is a bit far from the previously hoped level, so the theoretical background of innovation diffusion is presented to highlight crucial barriers (Miller et al., 2017; Barnes at al., 2019).

Then, we explore the concept of 'de-growth' and business in the context of the thoughts of Serge Latouche (2007).

The actuality of the topic is is also given by the fact that in the context outlined above, researchers have studied less the role of PA in sustainable development, in the context of the 'de-growth' theory.

THE CONCEPT OF SUSTAINABILITY IN AGRICULTURE – EFFICIENT LAND USE

Arable land is one of the key resources in agriculture and in the life of rural areas as well. Without going deeply into the question of resource limitation, here should be highlighted the need for increased efficiency of land use. From one point of view, efficiency has a technical meaning: yield efficiency for the given land, soil- and climatic conditions. The other is production efficiency, a term that is closer to economic efficiency and includes the questions of the market (demand, price, subsidies, etc.), farm facilities (property, ownership, size, market connections, memberships, geographical localization, level of capital and machinery, management skills, etc.).

Real efficient land use can be assessed from different perspective. From the wider aspect, land use cannot be set apart from the territorial, rural questions. The important role of small agricultural enterprises, not only in the economy, in employment, and in rural development, ensuring viability for local habitats and sustainable rural life is frequently mentioned (e.g., Tocco et al., 2014; Tudor, 2015). By 'efficiency' we will consider the economic meaning that is connected to the question of sustainability. During recent decades, the new paradigm of agricultural research and development has been built on the interaction of three factors: ecological sustainability, economic efficiency paired with equal opportunities, and mutual assistance of governmental and non-governmental sectors in order to improve the performance and profitability of farming systems (van Wijk at al., 2020; Takácsné, 2020; Venkatramanan et al., 2021). As effective farming meets will keep farmers living in rural settlements, it should be a pledge of social sustainability, too, at the same time.

Sustainable land use is linked with environmental protection in many ways. The land is the main, limited natural resource in agriculture (Steffen at al., 2015). To meet food security requirements for feeding the world, either with medium and high or only limited (i.e.) organic input use, economic efficiency (as defined above) is the criterion of land use. That should allow the producer to operate over the viable size. So that revenue covers all the costs – including the personal/family income at the average social level – and ensures the necessary investments (Kusz, 2018). By 'viable size', we mean that farming size (at certain production structure and yield level) when the given economic environment allows at least such income to be reached that covers all the production costs, including the necessary investment and ensuring the satisfactory standard of living for the farmer (Takácsné, 1994a and 1994b). The basic principle of a real market requires a farm to reach a viable size without subsidies.

Agricultural production with medium input usage should meet the restrictions, regulations and here, some provisions with the aim of environmental protection have to be implemented. The economic benefits can be increased by sparing and protecting natural resources, with no (or at least only at a low level (i.e., can be renewed)) pollution in the environment, in the frame of the system of sustainable development (Auernhammer, 2001; Stull et al., 2004; EIP-AGRI, 2015). The main characteristics of such agriculture are:

- Reduced use of water (precision irrigation),
- Energy-saving system,
- Optimization of chemical use (precision farming, site-specific),
- Appropriate technologies (to the given circumstances),
- Harmonized with the environment,
- Focus on quality production (including the questions of safety food),
- Importance of human capital, human skills (including IT usage) (Takácsné – Takács, 2017).

In other words, to be genuinely sustainable, land use should be sustainable from the point of view of land, soil, water, biodiversity (environment), from the economic point of view (how to be viable, competitive, giving enough income for the farmers, for the rural communities) and also sustainable in terms of social aspects ('Feed the world'– that was colling slogen of some conferences, workshops is the last decades) ensuring the social sustainability, too.

Also, should be mentioned the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development adopted by all United Nations Member States in 2015. It provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. It was recognised – over the limitaiton of natural resources – that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests (The 2030 Agenda for Sustainable Development, 2015).

During the last decades, more importance went to the broader meaning of the term 'sustainable development'. Over the main definition that 'sustainable development' includes the current and long-term sustainable production and the controversies of environmental protection that assurance the right quality of life, and difficult to prevent, but rather tolerated conflicts (WCED, 1987; Chilinsky, 1998; Turek, 2013).

The definition of sustainability of the environment comes from the Brundtland Report (WCED, 1987). Pearce and Atkinson's (1995) understanding is that the natural resources and human-made capital are complementary to each other in the production process, so that natural resources are creating the limiting factors to increasing production and, at the same time, they should be used rationally during production. By the turn of the millennium, sustainability has a broader interpretation:

- Protection of natural resources,
- Food production (fitting to the increasing demand),
- Maintenance of viable rural communities,
- Improvement of human and animal health (conditions),
- Environment protection ('polluter pays' principle),
- Suitable subsidy system(s),
- Diversity of land use,
- Less harmful territorial usage,
- Local solutions in territorial land (resource) usage,
- More efficient institutional background to ensure the multifunctional territorial usage ('territorial cohesion policy') (Tocco, 2014; van Wijk et al., 2020).

As it was mentioned before, the new paradigm of agricultural research and development has been built on the interaction of three factors: ecological sustainability, economic efficiency paired with equal opportunities, and mutual assistance of governmental and non-governmental sectors in order to improve the performance and profitability of farming systems. All the stakeholders should work together along this thought.

Social sustainability includes the necessary food production and industrially-based energy production, and also from the farmers' point of view, compliance with the profitability criteria, and the responsibility of sustaining the environment. Without economic sustainability, environmental and social sustainability cannot be realized in the long term. So, the question for the farms is how to operate efficiently, over the viable size. The responsible behavior of all participants (producer, consumer, and society) has to find a degree of intensity and technology of production matched with a form of farming technology that is appropriate for the environment, i.e. agroecology (such as organic, conventional, integrated and precision (a further developed form of integrated) farming strategies (Mawapanga and Debertin, 1996; Stull, 2004; Takács-György and Takács, 2011). To find the new ways of agricultural development and innovation it is also important to focus on a sustainable economy that is nothing else than social sustainability.

Innovation for the future – Why PA can be a tool of sustainable agriculture?

Innovation in agriculture is a complex process, mainly coming from the machine and chemical industry (pesticides, yield enhancer, etc.), plant breeding, irrigation systems, biotechnology, digitalization, managerial sciences, etc. gives a good base for the farmers to extend their knowledge and practice and find the appropriate way that meets the three pillars of sustainability. Innovation involves how the existing technology is used in production (field practices, livestock production), harvesting, storage, and pre-marketing functions such as sorting, drying, grading. Farmers are users of the results of other innovators, but when the adopt the new technologies they have to learn how to apply them, so they are also 'innovators' in their own farm.

The main characteristics of innovative farms are:

- up-to-date information and knowledge about facilities the farmer has (soil and weather parameters, technical efficiency, market prices, movements, etc.),
- appropriate technologies to the given circumstances (with a wide assortment from ecological production to site-specific production or individual feeding),
- reduced use of water (drip and precision (planed) irrigation),
- energy saving systems and renewable energy use,
- optimization of chemical use (precision farming, site-specific usage if needed, based on field experiences and prediction of degradation, etc.),
- harmonized with the environment (wild animal protection, shelterbelts, preserving biodiversity, etc.)
- focus on quality production (including the questions of safety food), meeting the market needs,
- meets the requirements of a safe food production chain,
- importance of human capital and human skills (including IT usage).

As precision (site-specific) farming is a holistic system, a technology that allows target-oriented treatments, thus managing the spatial and temporal variability within an ecosystem, by applying spot treatment applications. The technique of site-specific crop production means that we take into consideration the environment, like the endowment of the farms (soil parameters, fall, and precipitation, numbers of sunny hours, biodiversity, etc.), economic background (farm size, capacity, and level of equipment, capital sources, other facilities, etc.), management skills and use the seeds, chemicals, and other elements to optimize the resource use. Site-specific crop production is compatible with sustainability from ecological, economic, and social aspects (Wilson, 2000; Turek, 2013).

Higher is the spread of PA, higher will the positive impact on 'sustainability'. Though technology exists in farming practice in the last decades, new solutions are implemented from year to year as innovations, the spread of the technology shows different nature in the word. Due to the limitation of the paper here it is mentioned only the main factors that effects the dispersion of innovation.

INNOVATIVE SMART TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE

Technical development is a continuous process in everyday agriculture. Competitiveness technical and economic efficiency depends on the technical-development factors. The technical development of agriculture is based on four main pillars due to the definition of the European Association of Agricultural Economists (1955, Helsinki). These four pillars are the following: biological, chemical, technical, and human. The technical pillar includes engineerable, architectural development and the information-based decision methods, the new solutions for organization the processes. Innovation has a wider meaning: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. Due to the decades we left behind of the former metioned definition, a new factor to the formerly mentioned four ones of technical development in agriculture should be added: that is the question of the IT and the Big Data in the 21. century.

It is both a process and an outcome but there should be highlighted the role of the human factor in it. Who is capable of using all the IT-supported tools, who is able to make the best decision in time? As agriculture is a very complex eco-system, where the production is carried out in an ecological environment (soil, climate, certain agro-eco potential for yields), mainly based on and with a biological organism, on and in the land, using natural and artificial resources, technical equipment, etc. During the last decades – as the importance of knowledge has higher significance and the complexity of the technologies, equipment got more complicated – the human factor and organizational innovation got importance in the process of "implementation" of the innovation results in practice. The role of farmers, food industry in safe food production is high. They have to meet the requirements of consumers by applying the new solutions of Agriculture and Industry 4.0, facing with different risks. Their negative consequences of business risks can be reduced (or avoid) with knowledge and a good management attitude (Erdei et al., 2022). When a new technology is implemented into such a complex system, it is hard to reach economic efficiency. Efficiency has a technical meaning: yield efficiency for the given land, soil- and climatic conditions. The responsibility of the farmers means to find the appropriate crops, species and technologies from the point of view of agro-eco potential and to reach at least the so-called viable farming size. Here appears the role of innovation named as smart for sustainable development (Caffey et al. 2001; Mensah – Castro, 2004; Behnassi et al. 2011; Popp et al. 2018).

WHAT IS CLIMATE SMART AGRICULTURE (CSA)?

As the vulnerability of the agricultural sector to climate change is influenced by environmental and socio-economic factors, the CSA, as a global development goal, was introduced by FAO (2013) to guide the transformation of the agricultural system under the paradigm of sustainability. The concept of CSA couple's climate change and food security through the integration of adaptation (short term) and mitigation (long term) measures.

Among the technologies that are revolutionizing the present and that will define the future of agriculture, the most notable are:

Drones simplify supervision tasks for farms by being able to cover hundreds of acres in one flight, gathering, thanks to infrared technology, multispectral images, and a wide variety of information about the condition of the land, irrigation needs, crop growth, the existence of pathogens, and, in the case of cattle, the number of animals, their weight and possible anomalies such as lameness or unusual movements.

The *Internet of Things* (IoT) makes it possible to optimize the monitoring of farms, mainly through smart sensors capable of measuring everything from solar radiation to leaf moisture and stem diameter, or the temperature of each animal in the case of livestock, making it easier to make all sorts of management decisions.

Thanks to the ability of *Big Data* to analyze massive amounts of data, farmers can manage all the information obtained from drones, the Internet of Things, and other measuring instruments and integrate it both with historical information for the farm and with weather data, in order to optimize all stages of the production process.

Blockchain makes it possible to monitor crops and cattle from growth until handover to suppliers, improving, for example, the traceability of the supply chain. By using this technology, if an imported vegetable poisons consumers, the source of the outbreak can be easily traced, and only the affected products are withdrawn, instead of prohibiting imports of vegetables from the entire country of origin.

In agriculture, *artificial intelligence* and *robotization* are used mainly to interpret field images and apply fertilizers and pesticides with surgical precision or for dealing with weeds. On a farm, for instance, it means that microphones can be used to identify squealing piglets that are being squashed by their mother, and vibration can be sent to her through a sensor to make her get up (IBERDOLA, No year).

CSA aims to sustainably increase agricultural production, increase resilience to climate change, reduce GHG and other polluting emissions, ensure safe food production and food safety (FAO 2013; Aisenberg, 2017). Three pillars of CSA are the followings:

- sustainably increase agricultural productivity and income
- adapt and build the resilience of people and food systems to climate change
- reduce and/or remove greenhouse gas emission, where possible (FAO, 2013).

More technology and solution have impacted the above-mentioned objectives. Like integrated, precision crop-livestock management, use of renewable energy, use of legumes or cover crops, and practices which decrease soil degradation, increase soil carbon, to use also smart innovations based on new technological and organizational solutions applied to agricultural production, drones, teleoperations, etc. Both addressing climate change and transforming agri-food systems through all food-chain are the keys to meeting sustainable development (FAO, 2021). It was declared five crucial action points: 1. expanding the evidence base for CSA; 2. supporting enabling policy frameworks; 3. strengthening national and local institutions; 4. enhancing funding and financing options; 5. implementing CSA at field level as Climate-Smart Agriculture (CSA) has strong potential to contribute to the achievement of the 17 Sustainable Development Goals (SDGs). A critical precondition for realizing this scope is to identify potential synergies and trade-offs between the three pillars and the five implementation steps of CSA and the SDGs. These provide entry points for targeted CSA planning to enhance synergies and reduce trade-offs (van Wijk et al., 2020; FAO, 2021).

It is an expectation to grow the world's population by over 9 billion by 2050, mainly due to the growth in developing countries. Higher will be the rate of urbanization, more people will be living in cities (needed more water, more food to deliver into cities). By an FAO estimation, agricultural production will have to increase by 60 percent by 2050 from 2010 to satisfy the expected demands for food and feed. Agriculture must therefore transform itself if it is to feed a growing global population and provide the basis for economic growth and poverty reduction. Climate change will make this task more difficult under a business-as-usual scenario due to adverse impacts on agriculture, requiring spiraling adaptation and related costs (FAO, 2013). Adaptation to climate change – that is a real challenge – and to meet the lower emission aims requires an increase in efficiency, intensities per output will be necessary. Food security, mitigation of climate change and preserve biodiversity, more effective natural resource use (land, water) requires the turn to those agricultural production systems that allows more productive input use (from an economic aspect, too) and are more resilient to risks, shocks, and long-term climate variability. More productive and more resilient agriculture requires a major shift in the way land, water, soil nutrients, and genetic resources are managed to ensure that these resources are used more efficiently.

The task is to make the farmers adopt the technologies. Due to the limitation of the paper, the question of PA diffusion in practice will not be discussed deeply, and only the theory of barriers will be discussed. One should be highlighted here too that the expansion of the factors of agricultural technology development is closely related to general social development. Based on the literature, it was proved that PA is still a tool for farms to operate relatively efficiently and more competitively than before, but less focus went on the developing economies. The adoption should be started by some part of PA (soil and crop monitoring; site-specific fertilizer use, drip irrigation) supported by good agricultural extension via digital services (FAO 2013; Aisenberg, 2017; EIP-AGRI, 2021).

HOW CAN BE A PA A TOOL OF CSA?

Agriculture 4.0 term is several times used instead of Precision Agriculture getting close to the meaning of the term Industry 4.0. All the new tools technologies allow to improve farm profits and benefit the environment if applied correctly (Caffey et al., 2001; Neményi et al., 2003; Poppe et al., 2013; EIP-AGRI, 2015, 2016; 2017; Lencsés and Mészáros, 2020; Ślusarczyk et al. 2020). PA is the integration of modern technologies on farms, essentially facilitating doing the right thing in the right place and at the right time.

CSA aims to reduce vulnerability by improving the adaptive capacity of agricultural systems to climate stress and, hence, securing the provision of food while reducing GHG emissions from agricultural practices and land uses contributing to climate change (Brand et al., 2017). By other sources, Agriculture is liable for climate change as its activities account for nearly 13.5% of the total global anthropogenic Greenhouse Gas (GHG) emissions (Balafoutis et al., 2017) or over 24 % (Venkatramanan et al., 2021).

Cutter (2020) summarized how PA could help to reduce farm emissions. From the point of view of animal husbandry, for example, animal-related methane emission can be reduced by 10% reduced nitrogen utilized while 8% increase in yield in crop production due to the use of Variable-rate technologies (VRT). Farming efficiency in crop production can be increased by savings in both fuel consumption and input applications due to the machine guidance combined with VRT. If controlled traffic farming (i.e., documentation, organization) is applied, a significant reduction is expected in soil compaction and degradation (Vizzari et al., 2019; Späti et al., 2021). It is important to highlight that One tractor-based design of technology really can result in up to 50% reduction in GHG emissions in weed and pest control, so applying more items of PA technology, not only those advantages can be realized in an environment that was taken into the focus in the last decades (i.e., reduction of pollution, etc.) The most upcoming area of PA is precision irrigation, where variable-rate irrigation utilizes data, and feedback sensors, to apply irrigation more precisely (via drip, trickle or micro-spraying), utilizing lower pumping power, therefore, achieving water and energy savings and also reducing GHG-emission. Also, sustainable grazing methods that store carbon in the soil and prevent CO_2 emissions, using the local feed, and creating more circular systems on the farm can reduce the need for external inputs of fuel, pesticides, and fertilizers. In animal husbandry – over the PA advantages in feed production –

precision ventilation is an important area when considering indoor housing of animals as this is linked with high ammonia (NH_3) emissions. NH_3 emissions could be reduced by 60 - 65%. Precision feeding is a key methodology in improving individual animal productivity, and it has several decades history has become more popular, mainly because of its proven economic advantages. Automated milking systems allow the detection of mastitis early in lactation, helping farmers avoid reduced feed intake to milk conversion, which otherwise leads to increased GHG production per liter of milk as a suggested reduction of 2.5% to 5.8% (GWP) by decreasing clinical and sub-clinical mastitis cases (Balafoutis et al., 2017).

It should be taken into consideration the effects of the new solutions on land use and land prices and volatility of the land price. Feed production for animal husbandry is in contradiction with biomass/biofuel production for energy. Also, the change in consumers' habits (potential decrease in meat consumption) can lead decrease in GHG emission due to the decrease in animal husbandry.

CLIMATE SMART AGRICULTURE DRIVEN BY SMART INNOVATIONS' DIFFUSION

As PA belongs to Smart Agriculture, we show those factors of innovation diffusion that can characterize its spread in everyday practice. One of the most important factors that can speed up the diffusion and wider application of the innovation is its profitability (Samuelson, 1985). Others emphasize the effects of demand, the significant role of R&D (Freeman, 1972; Mohamed et al., 2010), or the role of the state (Pearce and Atkinson, 1995; Fenyvesi and Késmárky-Gally, 2012).

Based on Rogers' (1960) typology on the diffusion of innovations, we have characterized the precision crop production as an agricultural innovation: It can be described as follows, including some of the reasons for its slow diffusion in practice (Takács-György, 2012; Takács-György et al., 2013). In the launch phase, it had an advantage over the technological elements, which could have made rapid diffusion possible.

- Precision technology is less compatible, as farmers greatly vary in knowledge, skills, and attitude to innovations, as well as in farm size and financial background. The process of proliferation of the new technology is slower. In this respect, the Hungarian practice has several positive features, such as the successors of the production systems set up several decades ago and the counseling networks.
- The application of precision crop production must be considered from two points of view. Although the adoption of the element of the technology is not complex, it requires far more attention, a wider information base, and also more accurate work.
- The key figures of letting farmers learn more and test the new technology are the participants of agriculture and providers. (There are several specialists, scientific shows, and presentations organized annually in order to achieve wider diffusion.)
- Some of the benefits of precision technology can be observed directly (material saving, improved cost-effectiveness, yield growth), similarly to extra costs and investments. However, its indirect impacts, such as the reduction of the environmental load and increased food safety, are less obvious. If the positive impacts of the new technology are not obvious and measurable for farmers, and the perceived risk of its introduction is high, the technology will diffuse slowly, even when the financial background is sufficient.

The diffusion of precision crop production and its widespread application in practice is an economic decision from farmers' side when they have to invest their capital. The dynamic spreading of the technology can be expected in countries where there is a scarcity of human labor, the amount of arable land is not limited, the selling prices are high, while the rate of credit interest is low. In our opinion, it is of great importance to providing information for farmers, particularly information on the economic benefits of the technology. It is expected to build the elements of the technology in the newly merchandized equipment in the next future, but without strengthening the extension service and subsidies, the wider usage of precision weed control elements cannot be expected. Also, the maintenance of food security would be inconceivable without modern varieties and factors of production - including labor - efficient, productive enhancing technological solutions. Site-specific farming is a technology that uses fewer chemical ingredients, optimizes the resources (based on the characteristics of ecosystems), decreases yield uncertainty, and ensures effective production at the farm level. The documentation of precision technology creates the follow-up, food safety, which is also expected of the agricultural and food products for customers delivering. We agree that it is needed such developments and innovation directions contribute to food safety and safe food. With that, we will be able to produce the increasing food demand.

Following the initial phase, the role of interpersonal communication channels increases (e.g., discussions between experts), the farmer shows also can help to increase the farmers' knowledge of new technology (Csizmadia 2009; Maciejczak 2012). High is the role of positive attitude to the new technology, environment-conscious thinking besides the economic expectations in the success of individual decisions as the important factors can be mentioned, also the IT skills, aversion, or openness to the novelty, to new technologies the role of extension services and communications and other usefulness of novelty in the diffusion of technology. The causes of the slow-spreading process also include a lack of education and expertise (Takács-György et al. 2013; Lencsés et al. 2014; Kemény et al., 2017; Takácsné et al., 2018; Dobos and Benedek, 2021). The biggest problem with the application of new technology is that its possible advantages and disadvantages highly depend on the professional knowledge and attitude of the manager and the staff. Some of the benefits can be observed directly (material saving, improved cost-effectiveness, yield growth), similarly to extra costs and investments. However, its indirect impacts, such as the reduction of the environmental load, the surplus to CSA, are evident. These issues are less obvious. As long as the positive impacts of the new technology are not obvious and measurable for farmers, and the perceived risk of its introduction is high, the technology will diffuse slowly, even when the financial background is sufficient. The motivation factors of users play a key role in the adaptation of the technology. Aversion to the novelty and new technologies is a real barrier of the wider spreading besides the lack of financial sources to renew the equipment.

We believe that if precision agriculture can spread faster worldwide due to the formerly mentioned advantages, it can result in both individual and social utility coincidences that promote sustainability in a wider meaning.

Roy and George (2020) stated that main PA components (i.e., global positioning system; sensor technologies, geographic information system; variable rate technologies, grain yield monitors; crop management) support somehow sustainable agriculture. Macziejczak et al. (2018) also highlighted the main benefit comes from reducing the asymmetry of information coming from natural production systems and through reducing its vulnerability. Their application allows to reduce the environmental pressure and is connected with this risk of increased production failures (low yields) and negative external effects (pollution). It needs to be stressed that the issue of technology-driven development of CSA is crucial for the implementation of the sustainability paradigm in agriculture. The paper framed some important for this process issues, but further analysis, i.e., about constraints or tradeoffs are needed.

CSA – IN THE FRAME OF SOCIAL SUSTAINABILITY: THEORY OF ‘DEGROWTH’

The wide expanded interpretation of sustainability has a strong connection to the new paradigm: ‘degrowth’ (Latouche 2007; 2011). This new theory connected to the question of a sustainable future in the economy came to mind at the very beginning of the 21st century. The main meaning of ‘degrowth’ is not unknown to society. It is a movement towards a sustainable future, combining ecological economics, anti-consumerism, and somehow anti-capitalist thoughts. The roots of the movement go back to the antecedents: The Club of Rome report of 1971 entitled ‘Limits to Growth’. Estimates suggest the population will exceed 9.2 billion in 2050, and this is projected to increase demand for food by 50-70 percent, while the internal structure of consumption is evolving towards high-quality food. The Earth’s growing population generates increasing demand not only for the limited natural and artificial resources, especially food, energy, drinking water, but also for the liveable areas. To this must be added the question of migration due to climate change. For agriculture, the main task is not only to ensure food security but safe food and viable rural areas as well. In maintaining the above-mentioned aims, the economy, agriculture, and environmental management all have a significant role (WCED, 1987; Ryden, 2008; Mészáros, 2011; Popp et al., 2013; Takács-György and Takács, 2016; Takács-György and Takács, 2020).

Decades before the (re)appearance of the moral economists, an ethologist, Konrad Lorenz (1973), wrote his novel *Die acht Todsünden der zivilisierten Menscheit* (in English (1974): Civilised man’s eight deadly sins). The environmental, ecological, and social processes the author is referring to have some economic consequences for business life: degradation of biodiversity, decreases in agricultural and rural areas have huge effects on individual enterprises, on production structure, technology, the direction of innovation, etc. To be successful participants in business life, they need to give appropriate answers, trying to reach their optimal behavior. Though the increase in consumption can be a leading force of economic development, the question is: why increase the use of limited resources? What is the limit of the current usage? The limitation will increase the production cost, so many enterprises will leave the market if they would not meet the acceptance of the consumers. All the thoughts and questions are beyond themselves and in strong connection with innovation, with the capability to be renewed.

To summarize the main messages of Latouche (2007), we will use our former scientific publications (Takács-György - Takács, 2016; Takács-György et al., 2016; Takácsné, 2017; Takácsné – Takács, 2017). The principles of degrowth (Book: Petit traité de la décroissance sereine (in English: ‘Farewell to growth’) population growth is not the only cause of environmental problems. The allusion of this hides the ethical and moral questions which need common society action. In the view of Latouche, a revolution in culture and behavior is needed to degrowth. Some of the latest economic trends’ content to these principles. The necessary steps for degrowth are the following:

- *Re-evaluate*: in our age, the individualist megalomania, a rejection of morality, a liking for comfort, and egoism are agreed, and we feel it is normal. It is necessary to go back to the old ‘bourgeois’ values of honor, public service, the transmission of knowledge, ‘a good job well done’, frankness and mutual trust, respect for human rights, and nature and society. It is necessary to re-evaluate the idea of poor or rich and developing or developed.
- *Reconceptualize*: ‘We must, for instance, redefine the concepts of wealth and poverty; deconstructing an infernal couple of scarcity/abundance on which the economic imaginary is based is a matter of urgency.
- *Restructure*: adapt the productive apparatus and social relations to changing values. Make equitable policies in production tools and social sources. For example, some car factories need to be converted to make products for recuperating energy through cogeneration. The question is how much it costs and who will pay for it.
- *Redistribute*: it means the redistribution of access to natural heritage at the global, social, generational, and individual levels. Direct effects of redistribution weaken the power of the ‘world consumer class’ and especially the power and wealth of the big predators. It helps to solve the problem of distribution between North and

South and pay back the earlier ecological debt. Thanks to the redistribution, the developed countries can give an example and avoid the resistance of 'North' countries.

- *Relocalize*: producing on a local basis. Relocalization is an economic, political, and cultural issue. Fortunately, there are more and more positive examples for growth of local economies, such as direct marketing, short supply chains, and local service nets. The free movement of ideas is not restricted, but it is necessary to minimize the movement of physical resources. All production needs should be carried out at the local level. The 'Think global – Act local' philosophy is equivalent to the relocalize principle.
- *Reduce*: Reduce our habitual overconsumption and the incredible amount of waste. Think of the products which go together with social demand and artificial enkindle needs. The need to reduce the health risk and the prevention need to be placed in the foreground and recommended to change the 'mass tourism' to regional travel.
- *Re-use*: we must reduce conspicuous waste, fight the built-in obsolescence of appliances and recycle waste that cannot be re-used directly. The Olympic Basketball Stadium in London (2012) is a good example because it was the biggest temporary building, and after the Olympic Games, it was dismantled and sub-divided for reuse elsewhere.
- *Recycle*: recycling is part of our everyday life. There are many good examples of it, for example, the parts refurbishing program for Peugeot. In this program, the parts are renewed so that the price of service will be low, but the quality is the same. Another example is the waste cloth which is made from wastepaper. The secondary use of biomass energy is also a good example.

These principles could lead our life to another society where free cooperation and self-imposed rules are not a utopia. Re-evaluation is emphasized because this is the basis for the other seven principles. Cooperation should be exchanged for the competitive methods in the business and everyday life too. Latouche does not use the term 'coopetion' but his idea is equivalent to this. Egoism needs to be exchanged for altruism, and hedonism needs to be replaced by chivalry. It is necessary to change the aim of our life. The new aim will be the share of assets and not the getting of property. The tone could be on the social links and not on the consumption. To realize degrowth it is very important to reduce consumption, recapture reasonable production and increase the free time (and intelligent activities in the free time). According to Latouche, localization is a very important issue. His aim is to spread the ideology of local production and local consumption all over the world. Owing to the limitation, the concept of 'Consume less, share more' is only mentioned, without any discussion (Takácsné and Takács, 2017 53-55 p.).

Other economists (Fukuyama, 1995; Sedlaček, 2011) highlight the importance of learning the new principles of economic cooperation. The basis of cooperation is a moral economy instead of a benefit economy (Georgescu-Roegen, 1972, Daly, 1991). The role of cooperation, to share resources strengthen the market position with concentrated products, is an important element of current agriculture and farming (Wilson, 2000; Andersson et al., 2005; Szabó, 2010; Takács, 2012; Baranyai et al., 2014).

The concept of precision farming meets with the following thoughts of the 'de-growth' theory:

- Allows the efficient use of natural resources (***R****estructurer* – restructuring factors of production).
- Each farming strategy in which the farmers' cooperation is the base of an efficient machinery use (***R****estructurer* – restructuring of social relationships).
- Each technology that reduces the waste (going into water, land), by using less input, the human-health risk (***R****éduire* – reduction) shows into the direction of 'degrowth'.

The development, new knowledge, innovation should not let go into the direction of consumption increase exclusively. It should support the efficient use of limited resources and serve the development towards sustainability, preserving the good environmental conditions and fitting the changing social expectations. Other tools, as different farming strategies (organic agriculture(OA), which bans the use of agrochemicals and Genetically Modified Organisms (GMOs) or biotech-based agriculture (BTA, reliant on GMOs)) also shows into the direction of 'de-Growth', but it was not in the focus of this paper (Gomiero, 2018).

"Who wins?" – the question arose. It can be stated that for all participants of the economy/agriculture and rural territories, the sustainable operation means today: appropriate answers to changes, focusing on the future, finding new solutions, ways to reach the viable farm size from the point of view of farmers. On the other hand, the consumers need, the changing counsumer habits give a direction for the farmers, food, machinery,, chemical industry, which direction to innovate to.

Going back to the thought of Latouche, site-specific plant production is a tool to meet the expectations of "de-growth" theory in agriculture.

CONCLUSIONS

Climate Smart Agriculture is the future for our grandchildren to save the land and the Earth. The concept of Climate Smart Agriculture fits into the growing importance of sustainable development as a practical answer to call for economic viability, social inclusiveness, and environmental protection. It couples climate change and food security through the integration of adaptation and mitigation measures.

Using the limited (natural) resources as effective, the facilities allow, applying the results of new innovations, adapting farming strategies to the environmental challenges. That is the task of todays' agriculture – not a few! It is needed the variety of different farming strategies. The appropriate solution(s) can be based on up-to-date technologies, results of implemented innovations, traditional farming, taking into consideration local needs, cooperation among farmers to meet the requirements of globalization. Innovation and cooperation are ways for ensuring food security. Open innovation lets business partners and consumers share in the innovation process: coopetition instead of competing.

To be competitive in the agricultural market, the individual participants (i.e., the farms) have to be efficient. It is necessary to find and keep the consumers for the future, adopt new methods and solutions, and apply up-to-date technologies. The role of knowledge in improving – both the technical and economic – efficiency, strengthening the market and social connections, networks is high, but the success depends on the positive attitudes to change and the novelty of the people. The sustainable operation means today: appropriate answers to changes, focusing on the future, finding new solutions, ways to reach and keep the consumers at a viable farm size.

Why PA for? – It is one potential farming strategy as a tool to address all the three pillars of sustainability and is not far from the main messages of the 'degrowth' theory: the task is to find new solutions with sharing the resources and knowledge by cooperation. The new values (***R****éévaluer* – reappraise) suggest the intent of preserving nature at least in the current condition. Efficient use of natural resources (***R****estructurer* – restructuring factors of production) need the introduction of innovative solutions. Each farming strategy in which the farmers' cooperation is the basis of efficient machinery use (***R****estructurer* – restructuring of social relationships), each technology that reduces the human-health risk (***R****éduire* – reduction) shows into the direction of degrowth. In local economies taking part in resource sharing formations, cooperation, or in an open innovation chain – this is such behavior that meets some characteristics of the new paradigm of 'degrowth' and shows into the direction of a sustainable world.

It should be mentioned, that the successful farming highly depends on the management itself, so without changes in faremers mind, attitudes to novelty, to CSA, to new economic thought – i.e. 'de-growth' theory, blue economy, etc. – getting closer to sustainable farming will be a slow process. Education, the dissemination and spread of knowledge, and persuasion play a major role in the spread of innovation. The study was not intended to elaborate on this issue, that is the topic of further researches.

The connection between the 'degrowth' concept and the use of new, innovative technologies or turning back to traditional farming ensure food production with less environmental burden and less waste, and allows the increase of land use, and so somehow the strengthening of local society (local production – local consumption).

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