Judit OLÁH
Faculty of Economics and Business, University of Debrecen
József POPP
Faculty of Economics and Business, University of Debrecen

THE OUTLOOK FOR PRECISION FARMING IN HUNGARY

Case Study

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Abstract

For agriculture, precision farming represents the future - by increasing incomes and reducing the environmental burden at the same time. Precision management produces surpluses in yields, revenue, and profits, but not immediately. The additional income potential is expected to increase by 20% to 50%. Farmers mostly introduce precision farming in order to relieve workers. Although many farmers are afraid of using new technologies, the use of information technology in agriculture will be unavoidable. However, technology is fundamentally expensive, it is not widespread, and farmers currently use only a few elements of the technology available. Moreover, following the precautionary principle, technology used in farming covers only a part of their agricultural land. So farmers need to learn to produce more precisely than before, in a knowledge-based way.

INTRODUCTION

All over the world, technical development is closely linked to the production output of the national economy, and particularly the output of the agricultural sector. Nowadays, the elements of technical development are not just a factor in agricultural resources, but a condition without which modern, efficient, profitable and competitive production is unthinkable (Peszeki, 2001). Agricultural mechanization has increased rapidly in the last few decades (R & D), and the adoption of new developments in technology has become one of the key areas of effective, competitive production (Tóth& Túróczi, 2018). If the time devoted to the use of machines in farms is significantly extended, this will slow the introduction of new developments/ technology into the production process (Németi, 2003). Mechanization has a decisive role in agricultural production. In Hungary, after the change of regime, the purchase of new machines decreased, thus increasing the use of the machines already operating, and so creating a barrier to modernization. At the same time, agricultural mechanization has increased rapidly over the last few decades (Bratu, 2017).

Precision management is a combination of technical, informatics, IT and cultivation technologies that make crops (and livestock production) grow more effectively: all this is achieved while fulfilling environmental and sustainability expectations at a higher level (Gebbers & Adamchuk, 2010). Depending on the production goal, or by reducing input consumption (avoiding excess, increasing resource efficiency), precision management optimizes production or optimizes input consumption in treatment zones or in individual animals.

LITERATURE REVIEW

The first Industrial Revolution started with the invention of the first mechanical loom (1784) when many types of water- and steam-powered mechanical equipment were introduced. The second Industrial Revolution debuted with the use of the first conveyor belt in a pig slaughterhouse in Cincinnati (1870). Then mass production started with the use of electricity. The third Industrial Revolution began in the early 1970s with the spread of programmable logic controller (PLC). The introduction of electronics and IT (information technology) facilitated further automation of production. We are experiencing the period of the fourth Industrial Revolution today when cyber-physical systems come to the fore (Figure no. 1).

The agricultural revolution commonly refers to changes in the 18th century that resulted in a significant increase in the yields of the agricultural economy. However, this revolution was the result of the combination of many minor changes (technical and technological innovations) rather than a radical change in agricultural techniques.

Agricultural mechanization revolution: Mechanization of agriculture - the tractor replaced the horse in 1850.

2. Agricultural mechanization revolution: Introducing the shaft axle and hydraulics: the tractor became the universal machine after 1950.

3. Agricultural mechanization revolution: With the help of electronics, smart agricultural machines and devices were introduced after 1980.

4. Agricultural mechanization revolution: Today, a network of machines has been developed, which integrates the service and support agricultural work (Figure no 2).

The agricultural technologies used in the early modern age were widely used in the 11th- 12th century in Europe. These technologies included rotation farming (two crops in Southern Europe, three in Western Europe); at that time horses were introduced for ploughing and iron tools started to be used instead of wooden ones. Technical tools remained essentially unchanged until the end of the 18th century, and only the use of machines brought about changes at the end of the 19th century and in the 20th century. In this respect, the beginning of the late Middle Ages is much more revolutionary than the end of the early modern age. In fact, the changes around the turn of the first millennium AD could well be referred to as revolutions, as the agricultural technology which resulted in the rise of continental Europe was largely developed at that time. The only way forward is to increase efficiency and reduce risks (Lorant & Farkas, 2015). One of the most important tools to achieve this is digitization, i.e. the IT revolution, which has been taking place in many sectors and is now taking place in agriculture (Herdon et al, 2012). Zéman et al (2014) in their study (Trends in Hungarian agriculture) highlighted the importance of external financial resources in the development of precision agriculture. Agricultural enterprises are increasingly taking advantage of information systems in other areas, such as the application of corporate controlling activities (Hágen & Kondorosi, 2012; Shpolianska et al, 2017).

Precision agriculture offers many opportunities to increase productivity and profitability, even with shrinking environmental resources. In May 2000, the US government led by Bill Clinton ordered the abolition of disturbing signals from the Global Positioning System (GPS) of 24 satellites, which were previously needed for military and national security reasons. The decision changed life at one stroke, especially extending opportunities for civilian driving and, of course, agriculture. It now made sense to use mobile navigation devices in everyday traffic, because the 100m positioning accuracy dropped to 20m. The latest tractors and combines can even work independently (without an operator) with the help of their GPS-based devices. (Vinczeova & Kascakova, 2017). Using line guides and automatic steering – i.e. with the use of autopilot – sowing, fertilizer and chemical spreading, and other soil jobs can be achieved with 2-3 cm precision, essentially without overlaps or over-application, which alone results in 5-7% savings (Nadanyiova, 2016).

The technical conditions of precision crop production can be developed at the plant level by constructing an agricultural machinery park, with the addition of new units to existing machines, if these are technically suitable. New power tools and power plants are factory-ready or convertible at relatively low-cost for use in precision technology. When deciding on investment decisions – at the operational level – the anticipated use of technology must also be considered.

Over the past few decades, tractor manufacturers have been striving to develop ever-larger and more powerful machines, to be able to operate the ever-increasing number of pieces of farming equipment. Recently, however, the trend has been reversed; more and more companies are trying to produce prototypes of "insect-sized" agricultural robots. Smaller and fewer energy-efficient agribots (agricultural robots) capable of making decisions can be entrusted with tasks such as sowing, irrigation and harvesting, and are also capable of separating weeds from crops early in the initial growth period; for example, with well-directed laser beams, they are able to eradicate weeds as soon as they scanned them

The use of unmanned aerial vehicles, commonly called drones, is growing every year in agriculture. With modern drones, centimetre field resolution can be achieved, so detailed and accurate management zones can be created, meaning that parcels can be divided into smaller, relatively homogeneous parts that can be treated equally during subsequent interventions (e.g. nutrient replenishment). Drones navigate over the area under investigation and collect a variety of information with cameras and sensors mounted on them. Of these, perhaps the vegetation index (NDVI) is the most important piece of data; this informs us of the quantity of chlorophyll produced by plants (and thus of photosynthesis).

In Hungary today it is not easy to find suitably trained professionals, and agricultural education is less and less popular. In the future, agricultural education will continue to play a key role in preserving the income generating capacity of agriculture and in boosting its productivity (Máté & Darabos, 2017). Despite the fact that the domestic natural resources needed for agricultural production are good and / or excellent, agriculture-related occupations cannot be classified as "fashionable" professions among those making career choices (Holzer, 2017).

Countries involved in agriculture can be divided into three groups. One group consists of countries that can produce high returns at low unit costs (for example, the USA). Countries in the second group produce high yields (France and Germany) with high costs, while the third group (e.g. Hungary) can only achieve moderate yields at high cost. To increase the competitiveness of Hungary, precision management is needed, which creates a real link between technological processes, from basic cultivation to harvest.

The role of IoT (Internet of Things) is also growing in farming. These are devices that work with SIM card modems, so they can be used across the whole country on the network. IoT can help reduce feeding costs, assist in health care of animal (intestinal probes), forecast security incidents and map energy utilization (Wielki, 2017). The Moocall system is used in animal husbandry in Scotland. The device is fixed to the tail of pregnant cows and can signal the owner one hour before the cow gives birth, thus avoiding newborn animal mortality.

Farming 4.0 is a set of IT tools available today that are used in agriculture. Farming 4.0 includes a wide range of areas (from Excel tables to machine control), enabling companies to manage and operate their economic sector/business by using certain information technology tools. Farming 4.0 abolishes paper-based administration, and the moment it enters the system, it allows various contexts to be examined (Herdon et al, 2015). Database analysis can be a guideline for farmers to compare their performance with either their own data, or that of other companies in the region. In the future, the use of information technology in the agricultural sector will be unavoidable; in most places the data are digitally requested, so they can be analysed much faster, more accurately and in a more up-to-date fashion (Kovács et al, 2017).

THE SIGNIFICANCE OF PRECISION FARMING

Precision Farming or Precision Agriculture was initially intended only for arable crops, but nowadays it includes horticultural applications (Precision Horticulture, P. Viticulture) and precision livestock farming (P. Livestock Farming). Precision livestock farming uses the most advanced technologies to provide a maintenance, feeding and management system that, even on large farms, allows animals to be cared for individually, and problems to be detected early and resolved effectively (Tóth & Halas, 2016).

Precision crop production is a new technology system created as a result of the development of technical devices, complementing the fully mechanized technology of plant production with modern IT, GIS, computing and measuring equipment to form a uniform system. Precision crop production is realized in its full spectrum if all these elements are created: soil testing based on satellite-supported soil sampling; differentiated nutrient replenishment; yield map preparation; precision sowing; differentiated plant protection (Takácsné György, 2011).

Important tools for precision crop production are geospatial applications – GPS (Global Positioning Systems) and GIS (Geographical Informational Systems) – which have recently been introduced in agriculture with the spread of laptops with high-performance processors and a high storage capacity (Lénárt & Tomor, 2017).

The precision plant management system operates as a unit of 5 processes:

- data capture: measurement and recording of data on the parcel and the parcel sections;
- data collection and storage: gathering data from a particular parcel, or a certain area within a parcel;
- data processing: providing useful information for decision making;
- decision-making: determining the cultivation technology, detailing the cultivation, nutrient supply, sowing and other operations, together with the typical parameters and set-up data;
- carrying out an operation: the practical implementation of the decision making process.

However, the spread of precision farming may encourage hopes of higher profitability and agricultural supports to introduce technology (Kemény et al, 2017). In precision farming economies, a modest increase in specific profitability can already be observed. There is a mixed picture for specific costs, as in Hungary the shift from low input to precision cultivation requires an increase in input (e.g. seed) to increase yields. The use of labour *may* be reduced by the introduction of technology, but this is not automatically true. Increasing yields and improving the quality of produce are also legitimate expectations on the part of farmers. The number of farms introducing technology is slowly but steadily increasing while the technology used continues to evolve at the same time. We are currently in the upstream phase of precision technology (Singh & Rao, 2018).

Added value can be gained through precision management – often by using added inputs, with a very precise way of thinking and with strict technological discipline. Farmers who switch to precision farming will become long-term winners. But how can commercial banks respond to fast and frequent changes, and offer customers competitive offers, including the example of precision farming? Why does a precision farmer need to contact a bank? Because it is unavoidable: the United States of America are a good example, where initially only 5% of producers were involved in precision farming, but now (in a period of 15 years) this proportion has increased to 80%. The end product is always the same (for example, grain as a stock market product), regardless of whether it is produced by traditional or precision farming. The only question is whether the market pays for the method of production that we call precision farming. Commodity prices do not justify the added value of precision farming. With precision farming, lower fuel costs and lower environmental loads can be expected, but this is not necessarily paid for by the buyer or the commodity market (note that the Common Agricultural Policy supports agri-environment management, including the reduction of environmental impacts) (Kliestik et al, 2018). The future is one of efficient and competitive production, because the farmer will succeed if the harvest from one hectare increases steadily, with unchanged or decreasing specific costs. Financial and risk managers are counting on scales of numbers when they analyse the balance, but consideration is also given to natural aspects, i.e. what kind of production facilities and equipment (such as a machine park) exist, what kind of customer base the farmer has, and how many high yield fields the farmer manages? This is a different approach from the "purely" accounting approach. In the longer run, those farmers who move into precision farming will be the winners.

Another agricultural policy problem is the role of land prices in making land-use decisions. High land prices increase the capital costs of agricultural production, which contributes to the higher specific production value required to cover the increasing specific costs. Farmers mostly achieve this by using more intensive production methods, but this leads – or can lead - to deterioration in the quality of the land and its depletion. Competitiveness is a prerequisite for efficiency, and efficiency requires skilled workforce, while the rural unemployed are generally low-skilled. In Hungary, the level of education of those employed in agriculture is significantly below the level of employment of other sectors and the EU average (Kliestikova et al, 2017; Popp, 2014). Most of those with agricultural vocational training do not work in their profession, the popularity of the agricultural occupation is decreasing, and the agricultural sector is less attractive, although this does not necessarily mean a decrease in the attachment to agriculture (Dajnoki & Kun, 2016). Improving competitiveness is a more challenging task than maintaining subsidies. Human fatigue factor is minimized due to hands-off guidance leading to extending work hours and increased productivity. At the same time human workforce cannot be replaced by robotic tractors; instead it will require a quality replacement of workers able to handle new tools. In connection with the application of technology, generational tensions are the biggest problem. In the coming years, agriculture will be one of the sectors where the greatest technological change will take place. In essence farmers will oversee the system while the system does its job in the background. It will never be one hundred percent possible to exclude people from agricultural work, and robots will not be able to carry out all tasks.

The use of precision technology can be justified by other factors, besides the economic one: primarily its role in reducing environmental burden. Among the producer motivations, this aspect is less apparent than in the case of a transition to organic farming. The greatest limitation of precision farming is people. As subsidy in this area is less typical than subsidy for machine investments, it is important for the government and the European Union to promote the precision farming, but input suppliers have their share of responsibility. In Hungary, today, of the 5.3 million hectares of agricultural land about 2 million hectares are farmed with tools that are capable of some kind of navigation. There are great gaps in training in precision farming, but the biggest problem is that where there is training, there is no general curriculum for young people to learn from.

Much of the agricultural workforce fears advanced technology, let alone robots, although it is known that even though robots are challenging they represent an opportunity. Our only goal should be to ensure that the workforce benefits from the robot revolution. Firstly, it should be a source of pleasure that the workforce can be freed from heavy workflows while creating value. Automation will take over more routine work, including agricultural jobs.

Secondly, the poorer countries compete much more than Hungary on the basis of low wages on the world market; this approach can be competitive against higher wages for a time, but it can no longer compete against robots. It is advisable to switch from lower added value production to higher added value products, which means more innovation, new products and services, or the creation of industries where interpersonal skills dominate.

Apart from governments, companies, entrepreneurs, and individuals have a responsibility to adapt to automation. It is reasonable to increase the productivity of the workforce, so it is necessary to develop skills that robots do not yet have, or do not perform effectively. For this reason, companies can pay higher wages for such skills, but this implies a level of education that makes workers valuable in the labour market. It is primarily the responsibility of governments to transform education by focusing more on the acquisition of creative skills (competences) than on theoretical knowledge. This is a qualitative transformation where companies need to completely transform their training programs and workers have to adapt to this process. Not only will automation modernise the work environment but it will also contribute to the wellbeing of the workforce by shortening working time and improving work-life balance.

However, many farmers are still wary of using new technologies, even though in the future the use of information technology in the food economy will be unavoidable. With precision farming, overlapping and drop-out free solutions can be created, and the system will work well if we can apply it to large areas for every plant. The degree of ingredient savings expected from the application of site-specific pesticides depends on the heterogeneity, age and culture of the infection, and can reach 30-50%, or even in some cases up to 60-70% (Reisinger, 2012). This can both save on production costs, and significantly reduce the pesticide burden on the environment (Kuroli & Mesterházi, 2007; Takácsné György, 2011).

Its practical application (i.e. the proportion of land used, the elements used and the extent of the area cultivated by the producers), however, is far below the previously anticipated (pre-determined) level in both domestic and international spheres (Pedersen et al, 2004; Reichardt & Jürgens, 2009). According to the results of a non-representative exploratory survey carried out in 2012 on Hungarian farmers (Lencsés, 2013), the primary elements of precision crop production were the nutrition supply elements (soil sampling, site-specific nutrient application and yield mapping). According to a representative survey conducted in 2016, Hungarian producers described the high investment costs and the lack of information as barriers to the spread of technology; the spread is promoted if a detectably higher profitability can be realized after its introduction, and moreover, if the use of the technology is supported in some form by agricultural policy management. Of the producers surveyed, only 6.9% are considered farmers practicing continuous precision farming (Kemény et al., 2017).

THE RELATIONSHIP BETWEEN DIGITIZATION AND BIG DATA (DATA MINING) IN AGRICULTURE

By the term "big data", we mean complex technology environments (software, hardware, network models) that allow the processing of data sets that are so large and so complex that their processing with existing database management tools encounters major difficulties. Simplifying the term "Big Data" as a concept, it means processing a very large amount of rapidly variable and very varied data. "Big data" is not a specific technology but a synthesis of long-established and new technologies. These technologies collectively provide the ability to process and manage vast amounts of varied data over an acceptable period of time (Moravcikova et al, 2017).

The biggest technological leap in Hungarian agriculture occurred in the 70s, with the acquisition of the products and services of American large-scale technology chains and their related knowledge. At that time, with world-class technology, nearly twice the volume and quality of production was achieved. Today we are faced with a similar opportunity but now we cannot achieve success with the development of machine technology but through the development and distribution of infocommunication tools and the development of the appropriate level of knowledge associated with them. IT tools and applications support farmers in increasing the volume of production, improving quality and supporting efficient production, as well as supporting food consumers' ability to monitor products and promote environmental sustainability. In order to increase efficiency at a sectoral level, it is important that the service-providing applications are able to communicate and cooperate with each other so that human intervention is minimized.

Efficiency, growth in income and profit for individual product lines depend on a number of factors, but one decisive tool is the accurate and timely knowledge of production, production environment, data collection, database building and applications that support automated interventions and decisions, and the integration of all these aspects. The economic benefits of IT development in the Hungarian agricultural sector are currently unexploited. Existing developments work in isolation, and are linked to people, resulting in significant loss of data and data quality. The basic equipment of subsidized technologies includes tools which supply "intelligence", but they provide real economic benefits only with proper integration (Popp et al, 2017).

In addition to cost reduction, an important aspect is the increase in income, based on market data and information. The financers of product paths are the consumers who, through their expectations and decisions, determine the total income available on product paths. Informatics can connect consumers with producers through databases and analyses on the longest product paths. IT tools, solutions, applications, and services are all available (Füzesi et al, 2016). There are many examples of experiences from practical applications around the world.

In Hungary, the main obstacle to the penetration of IT solutions in agriculture is the human resource's lack of preparedness, skills and attitudes. Taking into account the number of farms, our industry needs 3,000 IT and agricultural engineers to design and operate applications, and educate and advise their users. An additional policy barrier is the lack of priority given to agricultural innovation, dissemination of existing products and necessary training and consultancy. The regulatory environment is not optimal either; it does not take into account the emergence of new technologies and their economic impact, thus making it difficult to access national data assets for business purposes and the use of drones for production purposes.

Most users do not currently have the skills to use IT systems at the user level. There is very little demand for the purchase and use of new systems. Lack of skills and competences also characterizes advisory networks, so the innovation product path does not reach the level of the producer. It should be noted that most of the leaders and decision-makers of state and chamber organizations for producers are not aware of the available options, either. Regulations do not take into account the development of technology, its application possibilities and their competitive advantages. Online administration, electronic identification, multiple requests for data, lack of data sharing (e.g. Agricultural Parcel Identification System – MEPAR), and limits on the use of drones are all areas that take away resources from producers or restrict access to potential benefits.

CONCLUSIONS

For agriculture, precision farming can represent the future, as it can simultaneously result in increased incomes and mitigation of environmental burden. Precision management produces a statistically justifiable surplus in yield, revenue, and profit, but not immediately. The additional income potential is expected to be between 20% and 50%. The introduction of technology also requires farmers to be willing to change and to undertake 2-3 years of knowledge-intensive learning. It is important to make use of the period of high income support and "cheap" investment (low interest rates) for learning and gaining experience. At the same time, there are still many obstacles to the spread of precision farming. These include high investment costs, lack of the required surplus funds necessary to introduce new technology, or the lack of available advice. Their role on the Hungarian market is hardly noticeable, but in line with international trends, it is an increasingly widespread phenomenon that IT systems, hardware, hardware + software units and IT solutions that represent complex business values receive financing (Darabos & Rózsa, 2015).

The spread of precision farming is influenced by a number of factors. Besides the heterogeneity of the natural characteristics (soil, terrain, climate, etc.), these include the size of the farm, the size of the parcels – or the possibility of being able to cultivate a number of separate parcels with individual plants (possibly several parcels owned by different

owners) –, and whether co-operation between producers will allow the critical threshold related to economies of scale to be reached (by common use of machines or services) (Takácsné György & Takács, 2018).
The increase in the number of precision crop farmers has accelerated over the past two to three years. Technology is fundamentally expensive, it is not yet widespread and following the principle of gradual development and being cautious farmers use only a few technological elements on their farms. So farmers need to learn how to farm more precisely than before. In order to exceed the expectations of agricultural experts as far as financing is concerned, precision farming cannot be limited to harvesting crops but also needs precision thinking in all areas of business operation, i.e. these enterprises have to operate "precisely" - humanly, agriculturally and financially.

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ANNEXES

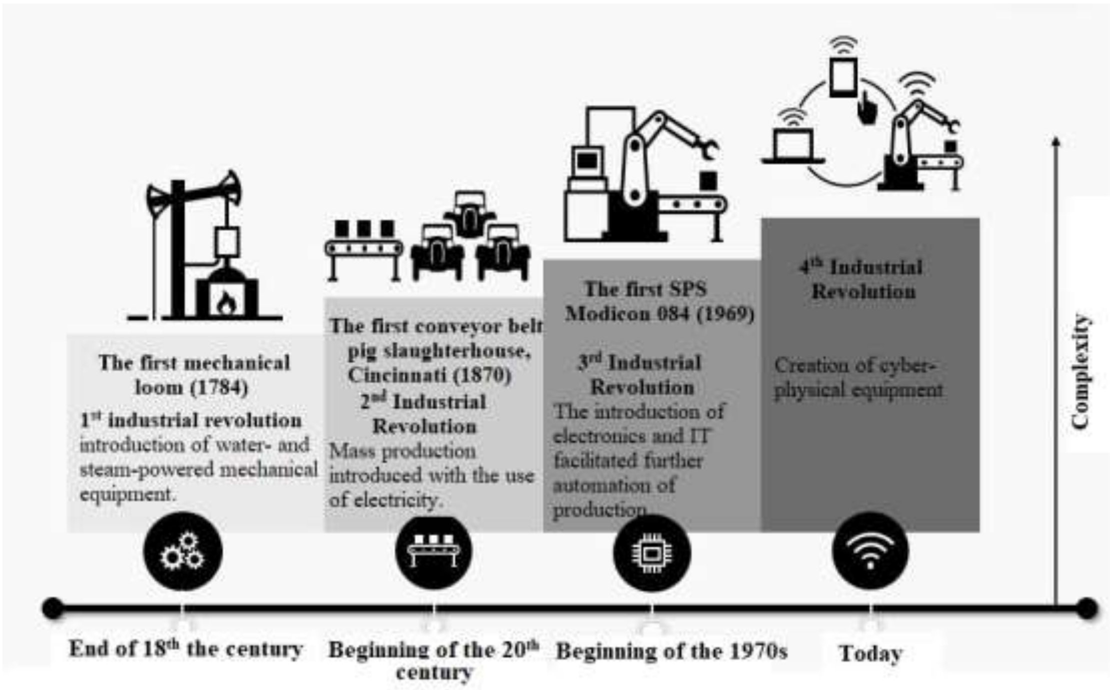

Figure no. 1. – Industrial revolution
Source: Author's own creation, 2018

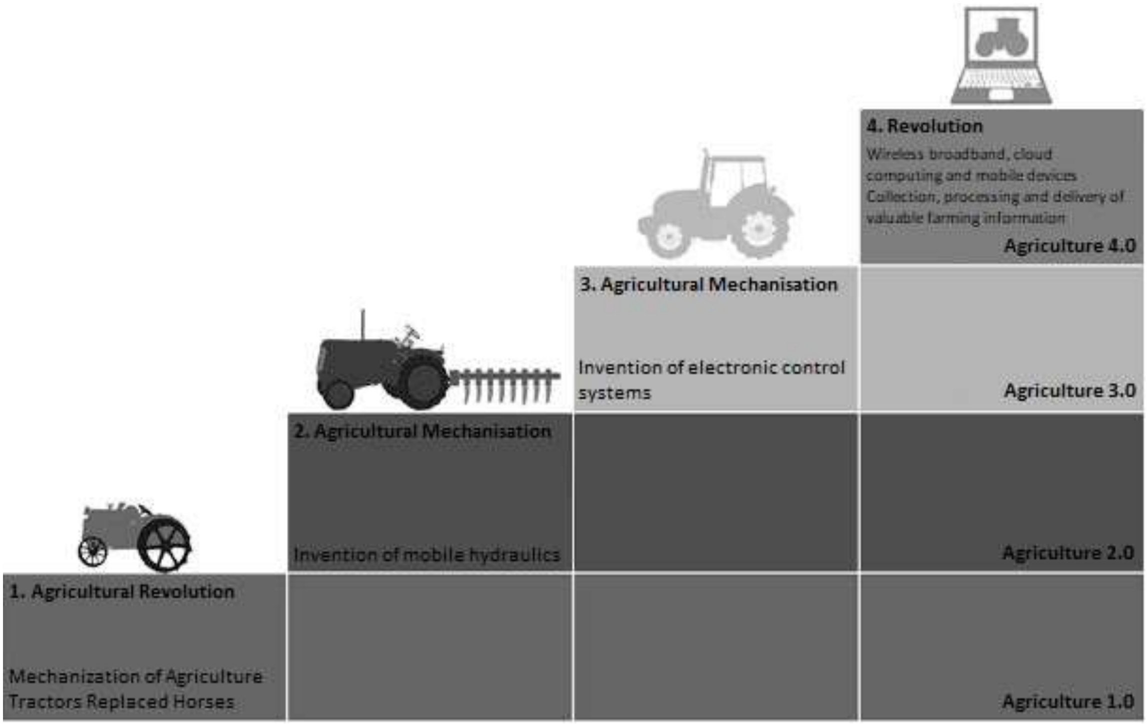

Figure no. 2. – Agricultural mechanization revolution
Source: Authors' own creation, 2018