ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering | e–ISSN: 2067 – 3809
Tome XVII [2024] | Fascicule 2 [April – June]

[1.]Vlad Nicolae ARSENOAIA, [2.]Iulian VOICEA, [2.]Florin NENCIU, [2.]Catalin PERSU,
[2.]Dan CUJBESCU, [3.]Viorel FATU, [4.]Corina MOGA

AGRICULTURAL SECTOR PERSPECTIVES AND TRENDS IN THE CURRENT GLOBAL CONTEXT

[1)] Department of Pedotechnics, Faculty of Agriculture, Ion Ionescu de la Brad University of Agricultural 8 Sciences and Veterinary Medicine, 700490, Iasi / ROMANIA;
[2)] National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest / ROMANIA;
[3)] ICDPP Bucharest / ROMANIA;
[4.)] Romanian Academy, National Institute for Economic Research, Center for Study and Research for AgroForestry Biodiversity "Acad. David Davidescu"/ ROMANIA

Abstract: Agriculture is an important branch of any national economy, with functions between the most diverse: biological, main source of economic activity and use of the labor force, ecological factor of environmental protection and combat against desertification in many areas of the Earth, a way of life, a technical tradition and cultural and, last but not least, agriculture is a side of civilization. Smart agriculture takes into account soil evaluation and environmental aspects from all perspectives and applies technological solutions for efficient fertilization, plant protection measures, and nutrient extraction. In recent years, the significant development of Internet of Things (IoT) technologies has made the integration of communication, automation, and control information into farms a very trendy "trend". Agriculture will be the field with the greatest digitization in the coming years; intelligence artificial in agriculture will be massive and unstoppable. The capability of drones is constantly expanding, the devices being equipped with high–definition photo–video cameras, thermal imaging sensors, infrared filming, parcel mapping and zoning systems, and simultaneously the volume of data increases fast. In the long term, "connected farms" will prove extremely valuable to the entire population of the planet considering the need to maximize production agricultural.
Keywords: circular economy, agricultural sector, globalization and liberalization, digital technologies

INTRODUCTION

"If agriculture is to feed the world, it must become an industry", said Geoffrey Carr, and fortunately, this has already begun to happen. The population is expected to grow to ten billion by 2050 – each year it will increase by the population of Germany (80 million) – so we must find a way to feed an additional 'Germany' every year, all while keeping agricultural land areas unchanged. This is not easy, especially considering urban expansion. For this reason, the world will need much more efficient farms to produce enough food: In the most modest scenario of economic growth, agriculture will need to grow by at least 50% compared to the current situation.

While extreme hunger and poverty have been reduced globally since 1990, there are still 800 million people suffering from chronic hunger and 2 billion people suffering from malnutrition. Agricultural growth remains generally three times more effective in reducing poverty than any other sector. In conclusion, if we think strictly in economic terms, there is a growing market for agricultural products, but we need to see if we have the resources to meet this growing demand (*Geoffrey Carr. et al, 2016*).

At an elementary level: food comes from plants, which not only feed humans but also animals. In recent years, plants in agriculture have become an important element in energy production. In fact, plants are experts at converting energy through photosynthesis. They transform solar energy into plant energy in the form of carbohydrates and fats, and then convert mineral nutrients into proteins and vitamins. Ultimately, the resulting biomass generates another form of "energy". All of these processes lead us to the conclusion that mineral fertilizers are crucial. In 2008, researchers at Wageningen University in the Netherlands demonstrated that mineral fertilizers are responsible for feeding over 50% of the global population!

Smart agriculture takes into account soil evaluation and environmental aspects from all perspectives and applies technological solutions for efficient fertilization, plant protection measures, and nutrient extraction. In recent years, the significant development of Internet of Things (IoT) technologies has made the integration of communication, automation, and control information into farms a very trendy "trend".

In the field of smart agriculture, introducing technology elements into farm management, such as tracking and monitoring the entire production process from crop establishment, processing, transportation, to sale, leads to incredible yields and quality in volatile climates with increasingly diverse natural disasters and diseases. In addition to population growth in the coming years, another aspect to consider when

discussing the future of agriculture is climate change and the increasingly advanced field of research.

The advantages of climate change include creating conditions for the cultivation of plants that could not be grown in Romania before. This includes exotic varieties originating from outside our geographic area that have gradually acclimated and can now be cultivated in our country, which was inconceivable just a few years ago.

The main issue for farmers remains access to financing. Despite undeniable progress in agricultural financing over the past 15 years, with diverse sources including funds allocated from the state budget, European funds, and an increase in bank credit and commercial credit, the approach of financial institutions toward agriculture remains cautious. In Romania, agriculture continues to hold a very important status, although it undergoes a process of property and exploitation system transformation. It remains one of the priority branches in the production of material goods, a vital and irreplaceable support for the existence and progress of human society, especially given that the economic and social progress of the contemporary world is closely correlated with the level of achievements in agriculture. It cannot be conceived without the strong development of this branch of production. Romania has approximately 9 million hectares of land, of which half are cultivated with modern technologies, although not yet at a Western level. Nevertheless, Romania achieved record grain production last year (over 10 million tons of wheat and over 15 million tons of corn), surpassing major players like France and Poland. Romania's potential in the field of agriculture is enormous. In a few years, Romania can play an essential role in the Black Sea region and in Europe's agricultural economy.

Precision agriculture is also beginning to take shape in our country. It is, in fact, an extraordinary opportunity for increasing productivity and, consequently, for increasing income. As a country with significant agricultural potential, Romania could become one of the top markets for harnessing IoT technology for the purpose of enhancing and streamlining agricultural production.

Understanding key global trends that can influence agriculture, the agri–food system, natural resource management, and rural economies in the coming decades is essential, given the importance of food in every society. Awareness of the impact these factors can have contributes to creating an agenda that strengthens the resilience and sustainability of agricultural systems.

The OECD defines megatrends as "slow–forming social, economic, political, environmental, or technological changes that, once launched, exert a profound and lasting influence on many, if not most, human activities, processes, and perceptions" (*OECD, 2016*). Presenting the main trends that can contribute to changing the configuration of agriculture and the agri–food system and stimulate innovation capacity in the years to come will follow the classification proposed by the OECD (socio–demographic, economic, environmental, technological, and political changes). When analyzing the influence and impact of current trends, such as population growth, urbanization, population aging, climate change, digitalization of economies, and the advancement of globalization and liberalization processes, their strong interdependence cannot be overlooked.

The absolute increase in the number of consumers, regional population dynamics, its structure by age groups, and by rural versus urban areas are variables without which understanding the evolution of the agri–food system is difficult to conceive. Demographics remain an important factor for the dynamics of all economic sectors. However, it is an essential parameter to explain the evolution of food demand, which depends on the number of consumers seeking to satisfy their vital physiological needs primarily.

According to the medium variant projection of the United Nations, it is expected that the global population will reach 8.5 billion by 2030 and 9.7 billion people by 2050 (*UN, 2015*). Therefore, food systems must ensure food security for an additional 2 billion people in the next 30 years. The largest demographic growth will be in less developed regions, in countries with middle and low incomes, influenced by the rate of economic growth, the level of education, the degree of female workforce participation, and other factors. In developed regions, the population growth rate is much slower or even declining.

MATERIAL AND METHOD

The decrease in the share of working–age people is a process that also characterizes developed countries. The central scenario of the OECD's long–term growth projection assumes

that the migration of young people across national borders could offset the aging decline in most OECD economies. In fact, several countries have already initiated immigration policies to compensate for job shortages in certain sectors (*FAO, 2018b*). These policies target three significant labor market gaps:

- highly skilled workers in high–tech sectors,
- workers to meet the demand for low–paid jobs that have become unattractive to local workers (agriculture and construction), and
- additional workers in the healthcare and other services due to an aging population.

By 2050, due to high economic growth rates and demographic structural imbalances, a major destination for migrants (especially from Africa) may become Southeast Asia and, in particular, China. Consequently, the size and importance of ethnic minority communities will increase, with specific challenges regarding dietary consumption patterns in these areas (*OECD, 2016*). Therefore, in these regions, increasing urbanization and changing working conditions will shape environmental and living conditions, and, as a result, food demand and eating behaviors in the decades to come.

The largest migratory flows are national migrations within state borders, typically from rural to urban areas, often as a consequence of rural poverty, lack of job opportunities, and poor infrastructure. The urban population has steadily increased over the past decades. Over 6 billion people are expected to be part of the urban population by the year 2050 (from 33% in 1960 to 62% in 2050), and nearly all of this growth will occur in cities in developing countries, with 90% of it in Asia and Africa. In absolute terms, this means a net increase of 2.4 billion people in the urban population, which is more than the total population growth during this period (2.2 billion) *(FAO, 2017a)*.

Urbanization brings many benefits to the population, such as access to electricity, improved water supply, better sanitation, educational opportunities, and it acts as a driver of domestic demand. On the other hand, the urban population generates a growing demand for processed and packaged food products. This leads to a shift in the nutritional content of diets, as processed products, often high in energy, sugar, and salt, influence obesity rates (*FAO, 2017b*). Apart from the impact on dietary consumption patterns, there are also issues related to the logistics of the agri–food system. Serving a large population requires high standards for food safety and logistics in the agri–food supply chains (*Satterthwaite et al., 2010*). One of the powerful consequences of this process, in the absence of rigorous regional development planning, is rural depopulation, increased costs of public services, decreased quality of life in rural areas, environmental degradation, and often an inequitable distribution of land *(FIT4FOOD2030)*.

The income level of the population plays a significant role in shaping the future of agriculture and the agri–food sector, as it represents the primary variable that influences the dietary consumption patterns of the population (*Godfray et al., 2010*). Higher rates of income growth per capita are expected in low– and middle–income countries. Economic development will be accompanied by an increase in the quantities and values of agricultural demand, as well as a change in the consumption pattern. The trend is a shift from a cereal–based diet to a diet richer in meat, dairy, and other resource–intensive food items (*Cirera and Masset, 2010; FAO, 2017b*), with implications for the sustainable use of natural resources.

Population growth, income growth, and changes in dietary patterns are among the primary factors that will impact future demand for agricultural products. At an annual growth rate of approximately 1.1% in global demand for agricultural products until 2050 (considerably lower than the 2.2% rate over the past four decades), the global supply of agricultural products by 2050 should be 60% larger than in 2005–2007, as suggested by certain projections (*Alexandratos and Bruinsma, 2012*).

Concerning the increase in agricultural productivity to meet global demand, there are no one–size–fits–all answers. Historically, global agriculture has been able to meet the growing demand for agricultural products over time. These improvements in agricultural productivity have been due to the use of irrigation, fertilizers, and the expansion of arable land. However, the sustainability of global agricultural intensification, given deforestation, land degradation, and water pollution, is a subject of concern.

Although agricultural efficiency has increased in recent decades, the pressure on agricultural land has intensified primarily due to demographic factors, changes in dietary patterns, and urbanization. When we add the competition between food and non–food uses of agricultural crops (such as biofuel production) and the loss of agricultural land due to erosion,

desertification, salinization, rising sea levels, etc., we understand the challenge of sustainable resource management to maintain their quality. A vicious cycle is created through the overexploitation of existing resources, their degradation, increasing pressure on the remaining resources, and further degradation of those resources (*FAO, 2017a*).

The agricultural land area per person has been continuously decreasing from 1.30 ha to 0.7 ha between 1967 and 2013 (*FAOSTAT, 2013*). There are regional variations in this phenomenon: in Asia, over the past few decades, increased production has been achieved almost exclusively through increased productivity, without an expansion of cultivated land, while in Africa, average cereal production has remained constant, but more land has become arable (*OECD, 2016*).

The expansion of agricultural land occurs at the expense of forests, savannahs, and natural grasslands, accompanied by an increase in greenhouse gas emissions and an acceleration of biodiversity loss. Agriculture is also, and is expected to remain, the largest consumer of global freshwater resources. Strong competition from the processing industry, electricity production, and household consumers will result in a 55% increase in global freshwater demand by 2050 *(FIT4FOOD2030)*.

Climate change will have a clear unfavorable impact, especially in countries in the southern regions, and its effects will be felt on both food supply and the quality and access to food. Changes in temperature and precipitation patterns can contribute to an increase in global food prices by 2050 (*Porter et al., 2014*), potentially reducing access to food for vulnerable populations (*FAO, 2017a*). Opinions on the impact on agricultural production in northern countries are nuanced, involving both positive and negative effects (*Porter et al., 2014*).

The increase in life expectancy, income, education levels, the digital economy, urbanized lifestyles, and more have influenced changes in consumer eating habits. The changes in consumption preferences today are significant compared to just one generation ago. Consumers are becoming increasingly concerned about nutrition, health, and sustainability in supply chains, carbon emissions, ethical considerations, and more. In other words, consumers are becoming more responsible regarding the impact of their choices.

The Center for Food Literacy defines food literacy as "understanding the impact of food choices on our health, environment, and economy "The prevalence of diet–related health conditions and allergies has increased awareness of the relationship between food and health. Health has become a major concern for consumers today and is often the primary motivation for food choices. Additionally, greater awareness of the origin of food has led to an increased demand for local or regional products. More transparency is being sought, with consumers wanting more information about ingredients, their origin, production methods, processing, and distribution.

Challenges related to increasing agricultural supply have been addressed so far through the intensification of agricultural land use, irrigation, and the use of chemicals. Global agricultural production tripled between 1961 and 2015. However, there have been negative effects on the natural resource base of agriculture, including land degradation, increased pest and disease resistance, loss of biodiversity, deforestation, greenhouse gas emissions, nitrate pollution, etc.

The growing demand for food, increased quality requirements, environmental considerations, and the need to avoid negative impacts on limited resources all require the development and use of innovative technologies for the future.

RESULTS

The use of digital technologies (such as 3D printing, the Internet of Things, cloud computing, robotics, etc.), along with the utilization of new materials (nano– and biotechnological), synthetic biology, and the large volume of accessible data (Big and Open Data), underlie the fourth industrial revolution (Agriculture 4.0) (FIT4FOOD2030). Digital technologies and new data analysis processes based on artificial intelligence will impact every stage of the agri–food chain: primary production, processing, distribution, and consumption (for example, through product selection and adapting diets based on the daily health parameters of each individual).

A multitude of remote sensing techniques, from field sensors to drones and satellite imagery, now provide real–time information about crop conditions. Robotics is explored in both primary production, from planting to harvesting (identifying weeds and diseases, precise pesticide application, and harvesting), as well as in processing industries.

Blockchain technology, recently used in the agri–food sector to track the trading of agricultural products, has an impact on the speed of transactions, transparency, and the efficiency of the supply chain. By interconnecting stakeholders along the supply chain, it ensures control and analysis of the journey of each product from the farm to the consumer.

A huge volume of data (Big Data) that covers various segments of the agri–food supply chain can be captured and analyzed (using sophisticated algorithms) to increase efficiency through the implementation of Internet of Food platforms (*Kouma, 2011*). This large amount of information and analysis influences current consulting systems. Social media has a significant role in gathering information about consumer behavior (digital shadow). Distribution can use this information to predict changes in demand for specific products and to generate differentiated, and even individual, pricing *(FIT4FOOD2030)*.

Open access to digital information tends to change business models, even for major and established companies in the agricultural product trade. For instance, if Cargill has built its market power over the past hundred years on the basis of limited access by farmers to market information, today, this information is available even to the most remote agricultural producers. This new context forces Cargill to reinvent itself, integrating intelligent applications for farmers into its offerings (such as facial recognition software for cattle farms), using new satellite data technologies for monitoring and assessing crops, and expanding its business to new sources of protein (aquaculture and cultured meat), taking into account the new challenges of the agri–food system (*Parker M., Blas J, 2018*).

Massive investments in Agtech companies in recent years anticipate the emergence of further innovations. The new markets created offer new business opportunities for entrepreneurs. It can also be an opportunity for emerging countries to reduce the technological gap, especially in the context of decreasing equipment costs and expanding open–source practices (*OECD, 2016*).

A massive transformation in the way agricultural businesses operate is expected, beyond what we used to call precision agriculture. However, the adoption of these technological innovations (even the adaptation of sustainable agricultural systems and practices) requires investments in research and development (R&D). Agricultural research intensity (the share of public spending on research and development in agriculture's contribution to GDP) is over 5 times higher in high–income countries compared to low–income countries (*Pardey, Chan–Kang, and Dehmer, 2014*).

The rate of economic growth in emerging countries and the expansion of communication and information technologies will strongly shape the evolution of this phenomenon, possibly even shifting the center of gravity of the global economy more towards the east and the south. This will also influence global governance structures to reflect the new configuration brought about by the multitude of participants in a multipolar economic world (*OECD, 2016*).

Until the early 1980s, the state played a significant role in shaping and marketing agricultural production in most countries. Governments were involved in the agricultural and agri–food market through intervention and control measures to generate fiscal revenues and, in some cases, to gain political control. However, since the 1980s and 1990s, many of these state intervention and control systems have come under pressure to liberalize. Nevertheless, in the last decade, new trade barriers in favor of domestic industries have been applied with greater frequency (*OECD, 2016*).

Globalization and liberalization have led to increased investments in agriculture, the development of the food industry, and the growth of international food trade. The increased global food flow, the development of global distribution networks, and the rise of private standards have significantly favored the concentration of primary production and the consolidation of agricultural lands, promoting the development of large farms (*Reardon et al., 2003*). However, this has also led to a constant erosion of food production systems and local food patterns (*Holden, 2018*).

The impact on agriculture and the agri–food system is the reduction of food losses and waste at all levels of the food chains. This indeed represents a systemic change in current methods of production and consumption, the relationship between producers and consumers, and that of "consumers with products and materials" (*Stahel, 2016*).

However, significant economic opportunities would be created, but political decisions and incentive tools are required to promote a circular economy. The transition to this paradigm involves

substantial costs for building the necessary infrastructure. On the other hand, the fact that this type of economic model operates more at the regional and national levels and is less reliant on import markets to meet demand makes it a viable alternative if reducing the trade deficit becomes a political objective (*OECD, 2016*).

CONCLUSIONS

Concerns about food security and safety have shaped the agricultural system, and these issues have been at the center of a series of food scandals since the 1990s (BSE, dioxin, avian flu, swine flu, etc.). This has led to the implementation of risk management systems and product tracking systems (traceability), and even the emergence of demand for special products (e.g., organic eggs).

Urbanization, the participation of most family members in the labor market, and time constraints have led to an increased demand for convenience foods. While often criticized, especially due to their low nutritional value and packaging waste, this type of food is experiencing significant growth today, driven by fresh–cut and packaged products.

The future of food products is about quality, taste, health, fresh and local products, as well as differentiation and customization. Various pressures on the agri–food sector, such as low consumer prices, raw material availability, increasing food safety regulations, health concerns, high innovation costs, etc., have created the need for economies of scale and led to strong consolidation processes within the sector.

Many mergers and acquisitions have taken place in recent years, resulting in the creation of massive corporations that exercise control over decisions within the agri–food system. New forms of regulation are required to mitigate the risk of unfair business practices, ensure the fair distribution of profits across the agri–food chain, and promote its sustainability.

In conclusion, the global trends and challenges facing agriculture and the agri–food system are manifold, and it is an opportune and necessary process for decision–makers, researchers, and businesspeople to reflect upon.

Agricultural and food production is expected to increase due to population growth and rising incomes. However, the expansion of the agricultural and agri–food sector can be significantly limited by the existing pressure on agricultural land and water resources. Innovative production models are required to enhance productivity while maintaining biodiversity and preserving the quality of natural resources. Sustainable production practices are demanded due to the increasing consumer awareness of sustainable and healthy consumption patterns. Success in shaping robust and resilient agri–food systems depends on intelligent strategies that can integrate digitization, new collaboration methods within the agri–food supply chain, and the circular economy.

Acknowledgement

This paper was financed by Ministry of Agriculture and Rural Development – Romania – MADR – Sectorial Project ADER 21.1.1 and Ministry of Research, Innovation and Digitalization through Program 1 – Development of the national research–development system, Subprogram 1.2 – Institutional performance – Projects for financing excellence in RDI, Contract no. 1PFE/30.12.2021.

References

[1] Alexandratos N, et al, (2012). World Agriculture Towards 2030/2050: The 2012 Revision, Food and Agriculture Organization of the United Nations, ESA Working Paper no. 12–03
[2] EC, 2018. European Commission. Circular Economy – Implementation of the Circular Economy Action Plan; European Commission: Brussels, Belgium, 2018.
[3] FAO, 2018a. The future of food and agriculture – Alternative pathways to 2050. Rome, 2018
[4] FAO, 2018b. The State of Food and Agriculture 2018. Migration, agriculture and rural development. Rome
[5] FAO, 2017a. The future of food and agriculture – Trends and challenges. Rome
[6] FAO, 2017b. The state of food and agriculture – Leveraging food systems for inclusive rural transformation. Rome
[7] FIT4FOOD2030. Report on baseline and description of identified trends, drivers and barriers of EU food system and R&I, Deliverable 2.1, Towards FOOD 2030 – future–proofing the European food systems through Research & Innovation.
[8] Godfray H., Charles J. et al.,(2010). Food Security: The Challenge of Feeding 9 Billion People. Science, 327, 812–818.
[9] Holden N.M., et al., (2018) . Review of the sustainability of food systems and transition using the Internet of Food. Science of Food, 2 (1), 18.
[10] JRC, 2017. Unfair Trading Practices în the Food Supply Chain.
[11] Kouma J.P., Lui L., 2011. Internet of Food. In 2011 IEEE International Conferences on Internet of Things, and Cyber, Physical and Social Computing
[12] Lee Smith, (2018.) The Top Global Trends, Driving the Fourth Agricultural Revolution, September 19, 2018, https://www.planet.com/pulse/top–global–trends–fourth–agricultural–revolution.
[13] OECD, 2016. An OECD horizon scan of megatrends and technology trends în the context of future research policy, OECD's Directorate for Science,
[14] Parker M., Blas J., (2018). America's Largest Private Company Reboots a 153–Year–Old Strategy, Boomberg Businessweek, 7 June 2018. (https://www.bloomberg.com).
[15] Pardey P., et al. (2014). Global food and agricultural R&D spending, 1960–2009. InSTePP Report. Saint Paul, USA, University of Minnesota.
[16] Porter J.R., et al, (2014). Food security and food production systems.

[17] Reardon T., et al. (2003). The rise of supermarkets in Africa, Asia and Latin America. American journal of agricultural economics, 85 (5), 1140–1146.
[18] Satterthwaite D. et al,, (2010). Urbanization and its implications for food and farming, Phil. Trans. R. Soc. B 2010, 365 2767–2767, volume 365, issue 1554, 2010
[19] Stahel, Walter R., (2016). The circular economy, Nature News, Nature Publishing Group, Mar 23. UN, 2015. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241. United Nations, Department of Economic and Social Affairs, Population Division (2015).
[20] Xavier Cirera, (2010). Edoardo Masset, Income distribution trends and future food demand, Phil. Trans. R. Soc. B 2010 365 2767–2767, volume 365, issue 1554, 2010

Note: This paper was presented at ISB–INMA TEH' 2023 – International Symposium on Technologies and Technical Systems in Agriculture, Food Industry and Environment, organized by University "POLITEHNICA" of Bucuresti, Faculty of Biotechnical Systems Engineering, National Institute for Research–Development of Machines and Installations designed for Agriculture and Food Industry (INMA Bucuresti), National Research & Development Institute for Food Bioresources (IBA Bucuresti), University of Agronomic Sciences and Veterinary Medicine of Bucuresti (UASVMB), Research–Development Institute for Plant Protection – (ICDPP Bucuresti), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and Romanian Agricultural Mechanical Engineers Society (SIMAR), in Bucuresti, ROMANIA, in 5–6 October, 2023.

ISSN: 2067-3809