

Technological Future of the Agriculture and Food Sector in Russia

LEONID GOKHBERG and ILYA KUZMINOV, National Research University Higher School of Economics, Russia

The global agriculture and food sector is changing rapidly because of the intensive increase of global food demand, which is in turn the result of population growth and significant shifts in consumer preferences. There is a clear need for improvement in the sector's technological, infrastructural, and institutional basis to ensure its sustainable development.

The situation is further aggravated by a number of environmental issues, including the degradation of ecosystems, biodiversity loss, and the deterioration of soil and sea productivity. Climate change leads to growing pressures on the agricultural productive areas and on the world's oceans. In the long term, there are significant risks of fertilizer deficits due to depletion of mineral deposits. Furthermore, declining pesticide efficiency due to the inability of agrichemical science to keep up with the pace of pests' evolution is an unfolding trend with serious implications. This creates risks for the globalization of agri-food trade, and it leads to a resurrection of 'food nationalisms' and intensifying economic vulnerabilities associated with the globalized trade.¹

Unfortunately, the new wave of technological advances (such as biotechnology, artificial ecosystems, circular agriculture, precision agriculture, robotics, smart logistics, and landless food production through the direct chemical synthesis of nutrients) rolls out rather slowly in many parts of the world. This is the result of a shortage of investment, political/societal/religious hostility to radical technologies, and inadequate labour force competences. Less expensive, yet highly effective, technological innovations and entirely new mechanisms for their promotion are required. The latter include the redesign of existing government policies related to science and technology (S&T), innovation, entrepreneurship, industrial organization, competition, and investment.

Having abundant land resources and significant industrial, S&T, and educational capacities, the Russian Federation (Russia) will, most probably, play an important role in combating the global challenges outlined above. To achieve this, however, the country will need to continue its reforms of the agriculture and food sector so that it becomes able to generate and absorb

technological and organizational innovations more efficiently.

Implications of global challenges

In today's deeply internationalized economy, global challenges are important elements of the strategic agendas of national agriculture and food sectors, although some national priorities are determined solely by domestic factors. The global challenges affecting the agriculture and food sector could be categorized, rather generally, into environmental, social, economic, political, and axiological (related to the values foundations of societies).² However, most of the challenges and trends, in terms of their causation, are mixed by nature.

First of all, a growing discrepancy between the dynamics of food demand and supply makes the future of agriculture rather difficult to predict. Rates of agricultural productivity growth are declining because there is now a 'technology pause' between the 'green revolution' and the emergence of future production systems, which promise to be highly efficient, agile, autonomous, and isolated from the natural environment.³

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The interlinked environmental challenges—which affect (and are partially produced by) the agriculture and food sector and threaten the stability of the world’s food supply—further aggravate the global food problem. As mentioned earlier, they include climate change, soil degradation, decreasing bio-productivity of the oceans, biodiversity loss, groundwater scarcity and contamination, reduction of the effectiveness of agrochemicals due to evolution of pests,⁴ and the long-term threat of exhaustion of mineral resources for fertilizers, among others. Therefore the trend of declining productivity growth rates can even evolve into declining overall production with dire consequences for the food security of developing nations.

There are also a number of socio-economic and values-based challenges. Among them are economic globalization and the volatility of global food markets affected by new, non-food uses of agricultural products, such as biofuels; the growing polarization of food consumption patterns as a result of income, cultural, and educational gaps; the transformation of the demand for labour in agriculture, which threatens the sustainability of the rural lifestyles; growing biosafety threats against the backdrop of the rise of ‘garage biotechnology’, or amateur biotech endeavours; risks to arranging guaranteed continuity of food supply for megacities and broader urban agglomerations; and many others.

The answers provided by S&T and innovation to the global challenges are expressed in terms of the rise of new platform (universal, or convergent) technologies.⁵ The developed nations demonstrate the rapid progress of radically new technologies (new generation sequencing, bioreactor-based synthetic food

production,⁶ total recycling, biocontrolled and artificial agroecosystems, vertical farms, swarm robotic intelligence, etc.),⁷ while the developing ones are still engaged in the adoption of the technologies of the previous wave (genetically modified crops, drip irrigation, and so on).

S&T and innovation processes are enabled by accompanying new business models made possible by modern information and communication technologies, which dramatically reduce both food losses and transaction costs in agriculture and food logistics. The diffusion of convergent technologies—including combinations of high-performance computation, broadband networking, and near-real-time data flows from satellites and aerial vehicles—seems to be one of the most important drivers of these organizational innovations.⁸

In parallel, technology development creates certain threats of large-scale disruptions for developing countries. These could be beneficial in the long term and on the global scale, but are harmful to short-term economic stability and food security at the national level. There are numerous ‘wild cards’ (or ‘black swans’) of this sort that refer to structural shifts with low probability but high impact for the agriculture and food sector.⁹ The diffusion of genetically modified organisms (GMOs) in global crop production and aquaculture could make exports of the non-GMO countries uncompetitive and damage their trade balance. Shifts in the natural habitats imposed by climate change can cause unexpected zoonotic events, which are negative for the animal husbandry sector. Synthetic food technology commercialization can radically shift the demand-supply balance for factors of production, such as agricultural land, resulting in financial turmoil in some countries.

It is particularly important to distinguish the opportunities and threats on the national level that are emerging from global challenges. Because of Russia’s circumstances and location, the global food problem, climate change, and the development of radical technologies tend to affect the country differently than the rest of the world, at least in the short term. Russia comes out ahead in this regard mainly because less technologically advanced and less industrially and institutionally developed countries often lose from global innovation in the short run, when they lose rents associated with inexpensive exports.

The global food problem is constituted of the global demand for food rising above limits of sustainable supply.¹⁰ It poses tremendous challenges to sustainable development, creating the risk of extreme famine events in Africa and South East Asia.¹¹ For Russia, with its vast land and water resources, the rising global demand for food provides a chance to establish itself in new international agriculture and food markets in circumstances when the markets of developed nations, being divided between producers from the United States of America, the European Union, Brazil, Canada, and Australia, are virtually closed for the country’s exporters.

Climate change, being disastrous for most subtropical and tropical agriculture and food producers because of higher frequencies of droughts, tsunamis, floods, and other extreme weather conditions, affects mostly non-agricultural areas of Russia, such as its Arctic regions. The impact of climate change on the main agricultural regions in chernozom (fertile black soil) and grey wood soil zones is mild and mixed, though the scientific consensus on the long-term net effects for Russia’s agriculture has not yet been reached.¹²

Diffusion of many promising technologies, such as genetically modified crops associated with much lower production costs, presents both opportunities and threats for the Russian agriculture and food sector—which is an established grain and oil seed exporter with a very conservative political stance towards GMOs. Recent progress in aquaculture (including recirculating aquaculture systems and plant-based fish feed) promise substitution of traditional, inefficient, and environmentally harmful sea fishing practices. In Russia, aquaculture technologies are quite underdeveloped, although its fisheries sector is one of the largest in the world. This situation creates economic threats to sectoral businesses in the northern and far eastern regions of the country.

In general, the described pattern is caused by excessive reliance on extensive production factors as a result of quite favourable natural prerequisites and insufficient attention to longer-term competitiveness factors related to progress in technology.

The Russian agriculture and food sector is sensitive to the situation in global markets of both the means of production (machinery, biomaterials, etc.) and the final products (grain, milk, meat, etc.). The capacity to both absorb foreign and domestic knowledge and to produce domestic innovations will be crucial to successfully facing the global challenges. Intensive investment and new initiatives in this field are needed for the agriculture and food sector to become more resilient. It must have less reliance on imported technologies, genetic material, veterinary drugs, fine biochemical and chemical substances, and less dependence on exports of agricultural raw materials rather than food products with high added value.

The status of the Russian agriculture and food sector

Russia is one of the world's largest producers of food products (e.g., grain, oil seed, and meat). Its output reached US\$80 billion in 2015, with exports of US\$16.2 billion. This sector has shown remarkable stability during the economic turbulence of recent years. Although the national economy has experienced some stagnation effects since 2014, the agriculture and food sector demonstrated steady growth rates of 2% to 3% per year, and the share of loss-making agricultural companies has continued to shrink, becoming significantly lower than that in many other sectors of the economy. Nowadays this sector is an important pillar of political stability on the national level, which is highly dependent on the wide availability of affordable food of good quality. Russia is almost self-sufficient in food: from 81% to 100% of internal demand for food (depending on the product category) was covered by domestic production in 2015. The agriculture and food sector is crucial for social welfare in the rural areas because it employs around 9 million people. It is anticipated that growth rates of production and exports could accelerate further because of the growing demand in developing countries of Africa and Asia for the food products that Russia produces.

Although the country has inherited a rather unbalanced and rigid agriculture and food sector from the Soviet era, post-Soviet institutional reforms allowed for the efficient reallocation of resources based on market competition and the adoption of state-of-the-art technological innovations. The optimization of supply chains was coupled with the concentration of production in the areas that were most favourable in terms of both their soil and climate conditions and their location. All

these factors allowed Russia to move from the brink of famine in the late 1980s to solid food security in the 2010s, and to significantly increase agriculture and food exports.

At the same time, the overall productivity of the sector remains relatively insufficient because of the uneven penetration of new technologies and the slow diffusion of the new wave of organizational innovations, such as digitization of trading and logistics, equipment time sharing, life-long learning, and so on. These factors underpin the slow progress of production intensification across certain regions, sub-sectors, and particular types of producers.

Other challenges include low demand for innovations produced by the domestic applied agricultural research and development (R&D), as well as weak communication between the sectors of education, S&T, and agricultural business. The latter does not demonstrate substantial demand for domestic R&D and technology, while research institutes and universities have been generally unable to provide a continuous supply of ready-to-use and commercially attractive technologies (they are more and more inclined towards research that is supported by public funding but that has no specific objective or orientation).¹³ Thus the positive effects of weak national currency for production and exports growth have been countered because a quick import substitution of significant part of technologies, equipment, chemicals, and genetic materials is not feasible. The challenge for domestic manufacturing of high-tech agriculture inputs, such as equipment, genetics, advanced fertilizers, and specialized information systems, is even more difficult to solve because of other barriers, such as economies of scale.

Of great importance is the sector-wide application of enabling

Figure 1: Propensity to introduce new technologies by economic entities of different types in Russia's agriculture sector

Technology to be introduced	Private farm holdings (self-sufficient farms)	Owner-operated farms/ individual enterprises (semi-commercial farming)	Medium agricultural enterprises, agricultural cooperatives (commercial farming)	Major agricultural holdings (commercial, export- oriented farming)
Organic agriculture	High	High	Medium	Low
Precision agriculture	Low	Low	High	High
Large-scale 'assembly-line' livestock breeding	Low	Low	High	High
Zero-tillage farming	Low	Low	High	High
Loose housing of livestock	High	High	High	High
Drip irrigation	Low	Low	High	High
Custom on-demand preparation of fertilizers	Low	Low	High	High
Integrated pest management	High	High	High	High
Urban agriculture (vertical farming)	Low	Low	High	High
Automation and computerization	Low	Low	High	High
Genetically modified and hybrid seed use	High	High	High	High
Biofuels	Low	Low	High	High

Source: HSE, 2017a.

Note: Likelihood of technology introduction: ■ High ■ Medium ■ Low.

technologies such as broadband digital communications,¹⁴ the Internet of Things, global geopositioning and other satellite services, unmanned aerial monitoring, smart digital trade infrastructures, robotics, biotechnology and bioenergy, and nanotechnology and new materials. However, efficient production systems based on the state-of-the-art technologies are concentrated within a limited range of large companies, mostly in the southern regions and around the largest urban agglomerations, while small producers in other areas are not able to absorb available technology innovations (Figure 1).

An answer to such challenges can be found in the re-arrangement of the sectoral innovation system, which is notable for its poor linkages between S&T organizations and businesses. Bridging the gap between academia and industry may allow Russia to become one of the major exporters of globally competitive high-quality agricultural products, production means, and services within two decades. There is also a need for closer technological cooperation and market integration with

other emerging economies, because this could allow Russia to gain access to large export markets for various means of agricultural production. No less important are further efforts to improve the domestic investment climate to attract direct investment from developed countries with gradual localization of high-tech products and technologies.

Prospects of S&T development

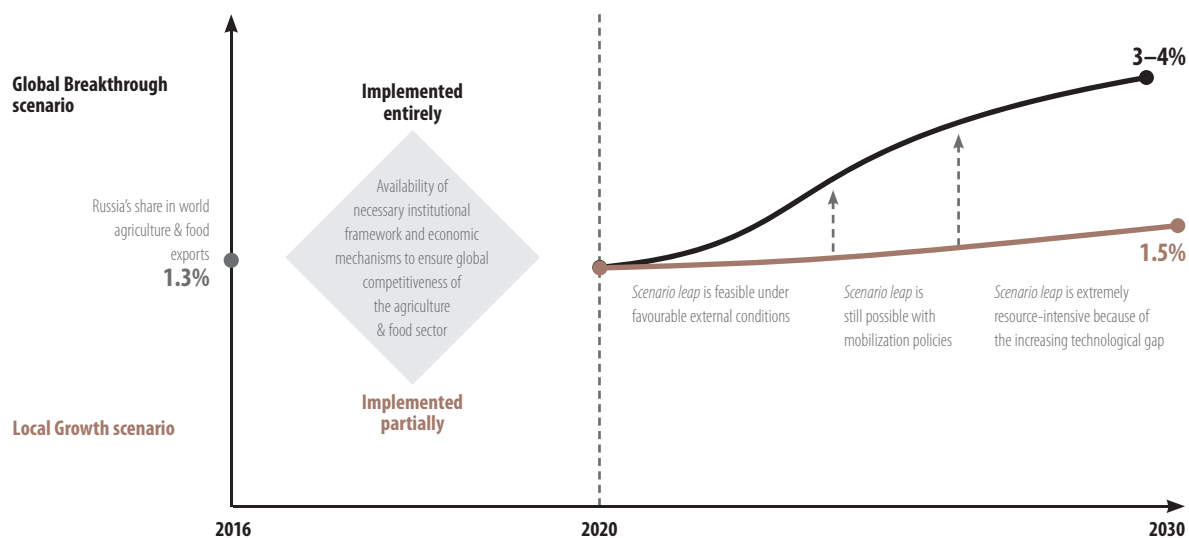
A complex picture of global challenges creates both threats and opportunities for Russia's agriculture and food sector. Whether Russian regulators, S&T organizations, and agriculture and food producers will be able to proactively adapt to threats and efficiently use evolving opportunities depends on the ability of different actors to clearly identify emerging global trends, map existing strengths and weaknesses, be agile in adapting the developmental strategies, and cooperate efficiently on a wide range of issues.

For the agriculture and food sector's stakeholders to become more able to participate in cooperative

future-oriented capacity building, the Government of the Russian Federation set the task of developing long-term S&T foresight of the agriculture and food sector in 2015. Depending on the future evolution of various global and national trends; the composition of existing strengths, weaknesses, opportunities, and threats; and the most likely policy choices made at key threshold points—macroeconomic, institutional, and political ones—two possible development scenarios can be considered for the period from 2020 to 2030.¹⁵

Russia can become a global supplier of high-value-added products, technologies, and services. This is the goal of the 'Global Breakthrough' scenario. Another option is less ambitious and easier to achieve, yet also desirable: this entails saturating the domestic market with competitive domestic products and technologies—the 'Local Growth' scenario. Both trajectories are possible and may start at the same point in time from identical external conditions. The difference between the higher and the lower trajectories is determined

Figure 2: S&T development scenarios for the Russian agriculture and food sector



Source: HSE, 2017a.

by the quality of the institutional framework and economic mechanisms by the year 2020; the gap between these trajectories will grow over time, making the leap from the less favourable scenario to the more ambitious one more and more resource-intensive (Figure 2).

In the Local Growth scenario, increasing commodity prices and devaluation-driven import substitution would stabilize the economy and allow it to return to a model of intensive imports of advanced technologies, equipment, and materials and large-scale exports of agriculture and food products. By 2020, the annual growth rate of the agriculture and food sector output would achieve 3% to 4% because of expansionary monetary and fiscal policies to help improve the investment climate. There would be a steady positive growth in the amount and quality of the harvest of most agricultural crops. In the food industry, a steady increase of output is expected. There would be a decrease in the growth rates of animal farming, which is affected by both the saturation of the internal market and the existing barriers to

export expansion. No significant structural changes in the sector and no intensive revitalization of national agricultural applied R&D based on cooperation with business would be expected (the level of non-public funding of agricultural R&D in this scenario could grow slightly from the current 17% to about 20%).¹⁶ Slow import substitution of basic and traditional technologies would continue, while dependence on state-of-the-art solutions would persist. The points of growth under this scenario would be traditional commodities markets, which would not require adaptations to shifts in consumer preferences.

In the Global Breakthrough scenario, the strong growth of the agriculture and food sector would be supported by reformed S&T and innovation policies, a sound institutional environment, and an efficient innovation infrastructure and would go hand in hand with timely structural changes in production chains. Because more efficient business models and new technologies would enable highly competitive production, no export barriers would hinder the expansion of the sector. Natural

resources (vast fertile lands, available water resources) and cheap yet high-quality domestically produced fertilizers would be utilized in full. The growth of the agriculture and food sector would be accelerated by 1 to 2 percentage points in relation to the Local Growth scenario. Significant structural shifts would be envisaged for S&T and innovation activities, particularly those that take place on the basis of effective stimuli for academy-industry cooperation. The share of non-public funding of agricultural R&D could reach 35% to 45%. Accelerated replacement of obsolete production facilities, tax incentives, and other benefits aimed at promoting high-tech import substitution could lead to an intensification of innovation activity. Increased competition due to saturation of the domestic market could also contribute to growth in innovation.

In addition to traditional markets, domestic producers would be able to occupy various highly profitable niches in knowledge-based services for the agriculture and food sector; among these are cutting-edge solutions in biotechnology, information

Table 1: Prospective S&T development areas for the agriculture and food sector

Traditional technologies	Emerging technologies
<ul style="list-style-type: none"> Accelerated selection, seed growing, and animal breeding technologies Traditional genetic engineering of agricultural plants and animals Vaccines, antibiotics, and antiviral drugs for animal farming Integrated pest management techniques and bio-pesticides Equipment for biosafety control throughout the value chain Technologies of compound, slow-release, and customized fertilizers Basic precision agriculture technologies (geopositioning, navigation, and digital maps) General-purpose agricultural machine-building technologies Technologies for the deep processing of agricultural and fishery materials^a Basic biotechnologies of food processing 	<ul style="list-style-type: none"> Next-generation sequencing and other advanced biotechnologies Technologies for sustainable, circular, and organic agriculture Advanced precision agriculture technologies (unmanned aerial vehicles, sensor networks, swarm robotics, artificial intelligence) Equipment for urban agriculture (recirculating aquaculture, vertical farms) Advanced waste utilization technologies, including next-generation bioenergy Smart agro-logistics, robotic storage, and transportation systems Technologies for the production of highly personalized and functional food Technologies for the production of synthetic and tissue-engineered foods

Source: HSE, 2017a.

Note: a 'Deep processing' refers to the production of high-value-added products with the use of sophisticated technologies—such as producing not only flour from grain, but also extracting amino acids from grain for the purposes of biotech industry; or producing pharmaceuticals from fish-based raw materials.

and communication technologies, robotics, aerospace, remediation of natural environment, and ecosystems design (Table 1). These would allow the sector to diversify overall output and secure export revenues. Technology-supported gradual transition from cycle-vulnerable business models of bulk commodities production to those based on the creation and export of intellectual property and tacit knowledge in various forms would also contribute to the sustainable growth of the sector.

Conclusions

The Russian agriculture and food sector may be defined as stable for the time being because of the strong institutional reforms that have been implemented during the last 25 years. Post-Soviet Russia has managed to establish an effective production-distribution system in agriculture,

thus deflecting the risks of acute food shortages and achieving food security. However, the current productivity level in agriculture is not yet satisfactory. Undoubtedly there is still room for improvement in the institutional design of the sector to resolve such negative issues as regional and sub-sectoral monopolies, administrative pressures on local businesses, high transaction costs due to deficiencies of the commodities exchange infrastructure, and so on. In addition, a number of problems concerning both the adoption of imported technologies and the development of domestic ones that would be competitive on the market need to be addressed.

Therefore the current main goal is to shift the agriculture and food sector from a sustainable production system to a sustainable innovation system. For this purpose, it is necessary to revive the sector's applied agricultural R&D capacity, making

agricultural R&D activities financially sustainable. Reforms aimed at the revival of applied agricultural R&D can be implemented only by promoting close cooperation between agricultural science and business under a suitable institutional framework. Fostering the ability of the agriculture and food sector to create new knowledge and technologies and promote them to competitive markets is a necessary condition for achieving the developmental parameters of the Global Breakthrough scenario. To this end, S&T and innovation policy for the agriculture and food sector in Russia must, within several years, evolve towards an evidence-based paradigm designed to encourage intensive development, resource efficiency, and environmentally sound practices; provide targeted support for innovating companies; and suppress the opportunities of benefiting from non-innovative rents (such as land ownership) at the cost of other market actors and consumers.

The scenarios described above will assist policy makers in establishing relevant measures for the uptake of technologies by national agriculture and food producers. Development of national S&T capacities will depend on proper institutional solutions and economic mechanisms for technology transfer and innovation; a harmonious system of S&T foresight and monitoring will play important role in this regard.

Notes

- 1 'Food nationalism' here refers to a government stance that emphasizes import substitution and protectionism in food and trade policy, so that the country primarily targets growth in domestic production to ensure food self-sufficiency for major products, rather than importing them from international markets.
- 2 HSE, 2017a.

- 3 The mainstream technologies of the 1960s (fertilizers, pesticides, and advanced selection) that were so effective in boosting production have become obsolete in terms of their inability to enhance productivity further at the growth rates demonstrated earlier. At the same time, many new technologies are being introduced rather slowly. Thus it is likely that there are currently only a few drivers that promise immediate and radical productivity growth in the sector.
- 4 Hassanali et al., 2008.
- 5 Sokolov and Chulok, 2016.
- 6 Bonny et al., 2015.
- 7 Gokhberg, 2016.
- 8 Aubert et al., 2014.
- 9 For a discussion about these 'wild cards', see Saritas and Smith, 2011; for a discussion about 'black swans', see Taleb, 2007.
- 10 OECD, 2009; Godfray et al., 2010.
- 11 OECD, 2013.
- 12 HSE, 2016; Saritas and Kuzminov, 2017 (forthcoming).
- 13 Termed 'non-oriented research', this is an activity without clear market-related objectives.
- 14 Suprem et al., 2013.
- 15 HSE, 2017a.
- 16 HSE, 2017b.
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