Agriculture and industry in Russia: Are there any indications of an entrepreneurial ecosystem?

Abstract. Ecosystems that allow obtaining synergistic effects from agreed actions of their participants recently have become the most attractive market patterns for the study. The paper tests the hypothesis about the presence of the ecosystem relationships between the agriculture and industry sectors in Russia. The methodological basis of the paper comprises the theories of ecosystems, entrepreneurship, complexity, and regional economics with respect to entrepreneurial ecosystems. The researchers apply economic-statistical and regression analysis to investigate crop growing and related industries of agricultural mechanical engineering and fertilizer production in the Russian Federation. The research data come from the performance of enterprises of these industries in 1990–2019. The central idea of the study lies in the assumption that to promote national economic development it is necessary to integrate the aforementioned industries in an ecosystem having single technological and digital standards. The findings of the empirical part demonstrate a weak correlation between the growth of indicators in crop growing and mechanical engineering, and simultaneously, a stable correlation between indicators of crop growing and chemicals industries. The constructed linear regression models evidence that in Russia the entrepreneurial ecosystem that integrates the agrarian sector with the related industries is at its early stages. The fundamental problem of organising such an entrepreneurial ecosystem is a systemic dependence of the Russian agricultural industries on institutional factors, primarily, on the government subsidies, and lack of the corresponding project solutions. The authors argue that the organisation of the entrepreneurial ecosystem bringing together agriculture and industry will foster another high-tech sector in the Russian economy.

Keywords: economic development; ecosystem; entrepreneurial ecosystem; agriculture; industry; agricultural mechanical engineering; Russia.

For citation: Orekhova S. V., Misyura A. V. (2021). Agriculture and industry in Russia: Are there any indications of an entrepreneurial ecosystem? Journal of New Economy, vol. 22, no. 3, pp. 69–83. DOI: 10.29141/2658-5081-2021-22-3-4

Received May 18, 2021.
Introduction

During the pandemic-induced crisis of 2020 the agro-industrial complex (AIC) was the only one participant in the national market of the Russian Federation that strengthened its position.

A number of factors contributed to the agro-industrial complex development. First, crop yields have risen steadily in recent years ensuring high profitability of agricultural companies, primarily due to the orientation of many of them to export. The agricultural sector’s positive dynamics owed to crop growing, in particular the production of cereals and oilseeds. According to the Federal State Statistics Service (Rosstat), the gross grain harvest in 2019 amounted to 121.2 million tonnes, being the largest one in modern history since the record crop of 130 million tonnes in 2017. The crop production in value terms reached 3.16 trillion rubles and increased by 14.66%1.

Second, 2020 saw an increase in prices for many types of agricultural products in world markets. Thus, export prices for wheat increased by 14–20 US dollars per tonne, depending on the class2 with the change in the dollar exchange rate in 2020 becoming an additional source of income growth for the export-oriented companies of Russia’s agro-industrial complex.

Finally, agriculture is now witnessing powerful processes of property consolidation. Business consolidation provides additional opportunities for investment, technical re-equipment and innovation. The strengthening of such industry giants as Cherkizovo Group, Rusagro Group, Miratorg Holding, Sodrugestvo Group, etc. increased competition in the market and, consequently, accelerated the transformation processes in agriculture as a whole.

Nevertheless, it should be understood that the economic success of one industry with decreasing efficiency in other sectors can lead to imbalances and, ultimately, to a drop in the performance of the entire national economic system. Since technologies are developing in the conditions of collaborations, joint use of resources and distributed production [Orekhova, Evseeva, 2020, p. 46], forcing individual industries and companies loses its meaning. The national economy can develop within the framework of entrepreneurial ecosystems as special market patterns united by common technological standards and formed on the basis of businesses associated with a single value proposition.

The purpose of the study is to check if there are any indications of an entrepreneurial ecosystem in agriculture and related industries. There is a stereotypical idea that enterprises of more high-tech industries should become a growth driver for their suppliers from other industries, thereby forming an ecosystem. We assume that the aggregating trigger of its formation may be another reason, for example, outstripping demand for

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1 Agricultural production in Russia increased by 4% in 2019 – Rosstat. *Dairy News*. 03.02.2020. https://www.dairynews.ru/news/proizvodstvo-selkhozproduktii-v-rf-v-2019-godu-uv.html (in Russ.)

2 Russian wheat export prices increased in 2020. Smart-Lab. https://smart-lab.ru/blog/657136.php (in Russ.)
products or favorable institutional conditions in a particular industry. An ecosystem business model will be an indication that the economic development of agriculture can produce a multiplicative effect that contributes to the development of the industrial sector and the Russian economy as a whole.

In line with the purpose the objectives are set as follows: (i) to identify the principles of ecosystem construction and explore the specifics of entrepreneurial ecosystems; (ii) to design the empirical part of the study and describe a method for analysing crop growing, agricultural mechanical engineering, and chemical industry.

The method of economic-statistical and regression analysis is used to assess the relationship between the economic results of crop growing and related industries in Russia. The final part of the paper contains the interpretation of the findings, as well as details the prospects for ecosystem integration of agriculture and industry.

**Entrepreneurial ecosystems: theory and origins**

The concept of the ecosystem approach formulated by Moore [1996] states that no economic agent can develop in isolation from the environment in which it operates.

The company’s activity is influenced by the connections that permeate the economic system, as well as the degree of the business participation in these connections. Therefore, ecosystems are understood as special market patterns [Gomes et al., 2018], within which a process of continuous formal and informal agreements between autonomous agents is unfolding, as a result of which rules are created [Thomson, Perry, 2006, p. 24].

This definition is consistent with the characteristics of ecosystems identified by Reeves, Haanaes, Sinha [2016, p. 47] – modularity, dependence, adaptation and coordination. Modularity assumes that the participants form parts of the value proposition independently of each other. At the same time, the value proposition is one whole for the consumer, due to which the participants depend on each other. Adaptation and coordination arise when each participant of the ecosystem adapts to it and simultaneously uses its technological and institutional subsystems, which include a production model agreed at all stages of the life cycle and a common environment for the exchange of information and resources [Seiger et al., 2014; Orekhova, Evseeva, 2020].

All ecosystems can be divided into four types: innovative, entrepreneurial, business ecosystems and platforms [Jacobides, Cennamo, Gawer, 2018]. The ideology of entrepreneurial ecosystems is described as a conceptual umbrella covering many different points of view on the geography of entrepreneurship [Spigel, 2017, p. 49] and is based on the literature on regional development, strategic management, entrepreneurship theory and a system approach. This relatively new research discipline investigates how local contexts form entrepreneurial behaviour [Fredin, Liden, 2020, p. 87]. The soaring number of papers within this subject area shows interest to apply this analytical structure in studies on economics and management. However, contemporary
research continues to develop theoretical understandings of the entrepreneurial eco-

systems phenomenon, construct and detail its substantial foundation, cf. [Simatupang,
Schwab, Lantu, 2015; Stam, 2015; Alvedalen, Boschma, 2017; Malecki, 2018; Roundy,
Bradshaw, Brockman, 2018].

Isenberg [2010] published the seminal work in the field of studying the entrepreneurial
ecosystem components, where he identified six factors forming these components: entrepreneurial culture, politics, financial aspects, human capital, market networks, and supports (Table 1).

| Components                          | Characteristics of the components                                                                 |
|-------------------------------------|--------------------------------------------------------------------------------------------------|
| Entrepreneurs                       | Characteristics of the business community in the region                                          |
| Government                          | The presence of effective institutions related to entrepreneurship (research institutes, foreign relations, public forums, dialogue between government and business). The presence of barriers to entrepreneurship (legislation on bankruptcy, taxation, contract execution, etc.) |
| Culture                             | Features of the mentality in relation to entrepreneurial risk and respect for entrepreneurship      |
| Success stories                     | The presence of business leaders in the region                                                     |
| Qualifications of employees in the region | Availability of professionals in the field of creating organisations, hiring and building structures, systems and controls, as well as professional members of the boards of directors and consultants |
| Sources of capital                  | Availability of financial sources for the equity capital creation. The presence of social capital in the region |
| Non-profit and industry associations | The presence of joint business support structures, professional and industry communities in the region |
| Educational institutions            | Availability of institutions and educational programs in the field of startups, entrepreneurship and doing business |
| Infrastructure                      | Characteristics of transport and communications in the region                                     |
| Location                            | The level of concentration of high-potential and fast-growing enterprises in the region. Proximity to universities, standardisation agencies, analytical centers, vocational training institutions, suppliers, consulting firms and professional consultants, etc. |
| Official and informal associations   | The presence of diasporas and their characteristics                                                |
In a number of papers, when clarifying the essence of the entrepreneurial ecosystem, the characteristics of entrepreneurs and new ways of allocating resources are emphasized [Acs et al., 2014; Mack, Mayer, 2016].

However, in the latest wave of research, the focus has shifted to the possibility of obtaining a systematic result due to a business model of this type, and the entrepreneurial ecosystem itself is interpreted as a complex institutional and hierarchical structure built in a certain way, consisting of various individuals and stakeholders, as well as different factors affecting the interaction between them [Mason, Brown, 2014; Autio, Levie, 2017; Spigel, 2017; Stam, Spigel, 2017; Cavallo, Ghezzi, Balocco, 2019]. Some authors suggest considering entrepreneurial ecosystems as complex adaptive systems. In this case, the research concentrates on the spatial and component boundaries of the system, self-management, the relational dimension between the system and its components, as well as the evolution of the system [Roundy et al., 2018; Fredin, Liden, 2020]. Orekhova and Evseeva [2020, p. 91] argue that complex adaptive systems are not an intermediate, but a central unit of analysis capable of nonlinear (multiplicative) self-development and self-renewal. This fact determines the structural complexity, which, in turn, is caused by the interaction of participants (organisational complexity), as well as increasing complexity, convergence and speed of updating production technologies (functional complexity). The components of the system can interact with each other in ways that are not always predictable, which leads to poor predictability of the entire ecosystem development [Arthur, 1999; Levin, 2002; Holland, 2006].

Along with theoretical research, the empirical understanding of the entrepreneurial ecosystem phenomenon is far from being complete. The study of ecosystems has not filled in research gaps and is generally regulatory and retrospective by nature [Mack, Mayer, 2016, pp. 2120–2021]. First, researchers have little idea of the causes shaping a particular ecosystem and the processes underlying its current state. Second, the institutional and political contexts in which the ecosystem develops are often ignored. Third, the existing works do not focus on the absence of any ecosystem components or the problems of their interaction. Finally, there is little discussion of the regional policy role in the development of entrepreneurial ecosystems.

| Components                              | Characteristics of the components                                      |
|-----------------------------------------|-----------------------------------------------------------------------|
| New enterprises and local offices of multinational corporations | The presence of a venture business in the region                        |
| Local consumers                         | The presence of potential customers in the region and their characteristics |

Source: [Isenberg, 2010, p. 5].
One more problem is added to this list of research gaps. Empirical studies almost always describe benchmark cases that are successful ecosystems, the cores of which are high-tech businesses (cf.: [Storper, 1993; Saxenian, 1994; Feld, 2012; Shermer, 2013; Trabskaja, Mets, 2019; Orekhova, Misyura, Kisliatsyn, 2020]). This approach significantly complicates the search for cause-and-effect relationships of successful or unsuccessful ecosystem development.

Nevertheless, a number of studies allow us to assess the state of ecosystems in the regions. Their authors use various metrics and approaches to monitor the presence of the ecosystem as such and analyse its state. Mason and Brown measure the growth of the ecosystem through the ratio of new businesses compared to dying ones, and the stage of the ecosystem life cycle through the level of entrepreneurs specialisation [Mason, Brown, 2014]. Stangler and Bell-Masterson [2015] define the density of the ecosystem as the ratio of the number of small business units to the size of the labour force in the region. Harrington’s work [2017] is aimed at measuring the connectivity of the ecosystem by assessing the intensity of interactions between entrepreneurs and infrastructure organisations. A similar problem was solved using other methods by Starikov, Evseeva and Voronov [2021], whose article defines a positive relationship between the technological development of Russian industrial regions ecosystems and the activities of the Industrial Development Fund. Zemtsov and Baburin [2019] measure the state of the ecosystem by the index of business provision with banking services. Chernova, Matveeva and Gorelova [2021] construct a model for managing the ecosystem of the water management complex of Russia.

Thus, the available studies comprehensively assess the impact of the local environment on the entrepreneurship development, but often do not analyse the relationship between the actions of entrepreneurs and the effects of these actions. The main purpose of this study is to try to assess such a relationship on the example of the agriculture and industry sectors in Russia.

**Study design and results**

The works described above are aimed at studying the characteristics of two blocks of entrepreneurial ecosystems: (i) the entrepreneurial core, which includes enterprises and close relationships between them; (ii) certain institutional conditions and infrastructure that create contexts for the ecosystem sustainability.

The empirical part of the presented research is focused on checking the presence of an entrepreneurial core (and, therefore, the grounds for the existence of an ecosystem) in agriculture and related sectors of Russia’s economy. We assume that the growing demand for agricultural products and the positive institutional context caused by the need to ensure national food security can become drivers for the creation of an agricultural entrepreneurial ecosystem.
The basic objective of the empirical part is to check the relationship between the sectors of crop growing, agricultural mechanical engineering, chemical and mineral fertilizers. The algorithm for solving this problem is shown in the Figure.

At the first stage of the study, the authors selected the relevant indicators for building models of dependence between the studied industries. Natural values of indicators for the studied sectors are used as metrics, since cost indicators can illustrate biased estimates and require additional verification procedures (in particular, clearing the price level from the influence of exchange rate differences, inflation, etc.).

The crop production was assessed according to the indicators of gross harvest, yield and crop area. In the field of mechanical engineering, the metrics for analysis were the number of manufactured units of equipment (tractors and combines). In the chemical industry, the indicators were the volume of mineral and chemical fertilizers produced for agriculture.
The data was collected for the period from 1990 to 2019. The source of information was the official website of the Federal State Statistics Service. Descriptive statistics are presented in Table 2.

### Table 2. Descriptive statistics

| Indicator                                                                 | Average value | Standard error | Median | Mode | Standard deviation | Sample variance | Asymmetry | Minimum | Maximum |
|--------------------------------------------------------------------------|---------------|----------------|--------|------|--------------------|-----------------|-----------|---------|---------|
| Tractors for agriculture and forestry, thousand pieces                    | 7.1           | 0.6            | 6.7    | 6.9  | 2.9                | 8.4             | 0.9       | 3.1     | 13.6    |
| Combine harvesters, pieces                                               | 6,362.9       | 291.1          | 6,241  | 8,059| 1,333.9            | 1,779,551.5     | 0.2       | 4,295   | 9,063   |
| Mineral and chemical fertilizers, million tonnes                         | 17.2          | 0.8            | 16.9   | 16.2 | 3.6                | 13              | -0.004    | 9.6     | 23.7    |
| Agricultural crop areas, thousand hectares                               | 80,525.6      | 1,907.3        | 77,853.7| -     | 8,740.2            | 76,390,214      | 3.5       | 74,697.6| 115,508.4|
| Yield of grain crops, hundred kilograms per hectare                      | 20.7          | 0.8            | 19.6   | 18.3 | 3.8                | 14.8            | 0.4       | 14.4    | 29.2    |
| Gross harvest of grain crops, thousand tonnes                            | 70,224.5      | 2,833.7        | 72,330 | -    | 12,985.5           | 168,624,316.4   | 0.01      | 46,994.3| 94,968.6|

At the second stage of the study, the authors carried out a correlation and regression analysis of the available indicators and built nine paired linear regression models. In each model, the indicators of crop production output (crop areas, crop yield and gross harvest of grain crops) were used as an independent factor, and the indicators of related to crop growing industries were used as dependent variables.

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1 Agriculture, hunting and forestry. Federal State Statistics Service. https://rosstat.gov.ru/enterprise_economy (in Russ.); Industrial production. Federal State Statistics Service. https://rosstat.gov.ru/enterprise_industrial (in Russ.)
According to the main hypothesis of the study, if an entrepreneurial ecosystem is there, an increase in the production indicators of the crop growing will entail an increase in the production volume in related sectors of agricultural engineering and chemical fertilizers production. Since this growth will be a reaction to the growth of crop growing indicators, it is advisable to take into account the time interval in the model. The calculation was made using an annual time lag, but in further studies it is also possible to calculate long-term effects. The results of the correlation and regression analysis are presented in Table 3.

Table 3. Results of the correlation and regression analysis

| Variables | Coefficient of correlation | Coefficient of determination | Significance $F$, % | Coefficient at X Intercept |
|-----------|----------------------------|------------------------------|---------------------|----------------------------|
| Models of dependence between crop growing and agricultural engineering industry | | | | |
| $Y$ – tractors, $X$ – crop areas | 0.089 | 0.007 | 70.1 | 0 | 4.746 |
| $Y$ – tractors, $X$ – crop yield | 0.044 | 0.001 | 84.9 | -0.033 | 7.815 |
| $Y$ – tractors, $X$ – gross harvest | 0.102 | 0.010 | 65.9 | 0 | 8.733 |
| $Y$ – harvesters, $X$ – crop areas | 0.033 | 0.001 | 88.6 | -0.005 | 6.772.2 |
| $Y$ – harvesters, $X$ – crop yield | 0.429 | 0.184 | 4.9 | -148.706 | 9,436.17 |
| $Y$ – harvesters, $X$ – gross harvest | 0.327 | 0.107 | 14.8 | -0.034 | 8,722.93 |
| Models of dependence between crop growing and chemical industry | | | | |
| $Y$ – fertilizers, $X$ – crop areas | 0.577 | 0.333 | 0.6 | -0.0002 | 36.84 |
| $Y$ – fertilizers, $X$ – crop yield | 0.821 | 0.675 | 0 | 0.787 | 0.967 |
| $Y$ – fertilizers, $X$ – gross harvest | 0.261 | 0.068 | 25.3 | 0 | 12.032 |

The analysis resulted that none of the assessed relationships between agricultural engineering and crop growing has a high level of correlation, as evidenced by low correlation coefficients. The authors also established that the models of dependence between tractor production and the indicators of crop yield and gross grain harvest are statistically insignificant, as evidenced by the probabilities of the null hypothesis (65 % and higher). This result suggests that the growth of crop production does not stimulate the growth of tractor production in Russia.
The models of dependence between the combine harvesters production and the indicators of crop yield and gross harvest of crop production were statistically significant at the levels of 5 and 20 %, respectively. At the same time, the correlation coefficients indicate the average level of dependence between the studied indicators.

Consider the model of dependence between the combine harvester production and crop yield:

\[ Y_{t+1} = 9436.17 - 148.706 \times X_t, \]  

(1)

where \( X_t \) is the yield of grain and leguminous crops in the Russian Federation in the year \( t \); \( Y_{t+1} \) is the number of grain harvesters produced during the period \( t + 1 \) year.

The correlation analysis revealed an average level of correlation between these indicators. The model (1) also shows that there is an influence of grain yield on the production of harvesters, but this influence is negative. The modeling results allow us to conclude that with an increase in the yield of grain crops by 1 hundred kilograms per 1 hectare, the number of harvesters produced decreases by an average of 149 units. The significance of the regression model coefficients is at the level of 5 %.

The second model under study is the model of dependence between the combine harvester production and the gross harvest of grain crops:

\[ Y_{t+1} = 8722.93 - 0.034 \times X_t, \]  

(2)

where \( X_t \) is the gross harvest of grain and leguminous crops in the Russian Federation in the year \( t \); \( Y_{t+1} \) is the number of grain harvesters produced during the period \( t + 1 \) year.

Model (2) also demonstrates the negative influence of the gross harvest of grain crops on the number of combine harvesters produced. With an increase in the harvest per tonne, the number of combine harvesters produced decreases by an average of 0.03 pieces. The significance of the regression model coefficients is at the level of 20 %.

There may be several reasons for such a low correlation between the production results of crop growing and agricultural engineering. According to the Strategy for the Development of Agricultural Engineering in Russia for the Period up to 20301, to replace the agricultural machinery fleet in the country, taking into account the retirement of old machines, it is necessary to buy more than 50 thousand tractors worth more than 300 billion rubles and more than 18 thousand harvesters with a total cost of more than 140 billion rubles annually. The average age of a tractor in the Russian agricultural machinery fleet is 19 years. Such a significant depreciation of fixed assets cannot be compensated quickly enough, during the year following the harvest.

Another reason is the fact that the lion’s share of the agricultural machinery market in Russia is occupied by foreign enterprises, among which Belarusian and American

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1 On approval of the Strategy for the development of agricultural machinery in Russia for the period up to 2030. Decree of the Government of the Russian Federation 1455-p of July 7, 2017. http://www.consultant.ru/document/cons_doc_LAW_219731/ (in Russ.)
manufacturers are the leaders. It can be assumed that with an increase in yield and, accordingly, an increase in profit, farmers buy more expensive imported agricultural machinery.

The second group of models allows us to determine the interdependence of crop growing and the chemical industry. There is a high level of correlation between the production of fertilizers and crop production in terms of yield and an average level of correlation in terms of crop area. Thus, in this part of the proposed ecosystem, there are stable links between the studied industries.

The significance level of the model assessing the dependence between the production of mineral and chemical fertilizers and the crop area as well as its coefficients is 1 %, which indicates the reliability of the results obtained:

\[ Y_{t+1} = 36,838 - 0,0002 \times X_t, \]  
(3)

where \( X_t \) is areas under agricultural crops in the Russian Federation in the year \( t \); \( Y_{t+1} \) is the amount of mineral and chemical fertilizers produced during the period \( t + 1 \) year.

Model (3) shows that with an increase in the number of crop areas, the number of fertilizers produced on average decreases by 0.2 thousand tonnes. The significance level of the regression model coefficients is 20 %.

The model assessing the dependence of the mineral and chemical fertilizers production on the yield of grain crops and its coefficients also has a significance of 1 %, which confirms the reliability of the results obtained:

\[ Y_{t+1} = 0,967 + 0,787 \times X_t, \]  
(4)

where \( X_t \) is the yield of grain and leguminous crops in the Russian Federation in the year \( t \); \( Y_{t+1} \) is the amount of mineral and chemical fertilizers produced during the period \( t + 1 \) year.

The correlation analysis of the model (4) illustrates a strong positive relationship between the selected indicators. With an increase in yield by 1 hundred kilograms per hectare, fertilizer production increases by an average of 787 thousand tonnes.

The results of the regression analysis demonstrate the emergence of the entrepreneurial ecosystem “agriculture – industry” in Russia. According to the first indicator under study (the production of tractors), the relationship has not been established. This means that the growth of agricultural production does not affect the production of tractors for agricultural needs. According to the second indicator, the negative influence of the grain harvest growth on the production of combine harvesters was revealed. In other words, the growth of agricultural products does not stimulate the growth of domestic agricultural engineering production. At the same time, the presence of an ecosystem is confirmed by the results of the analysis of the agricultural development influence on the production of mineral and chemical fertilizers.
Conclusion

The concept of entrepreneurial ecosystems by itself does not offer new ideas, but opens up a new perspective by combining the research results presented in various scientific articles [Stam, 2015]. The study found that an entrepreneurial ecosystem “agriculture – industry” is emerging in Russia, and institutional and infrastructural conditions can foster its accelerated development.

At the same time, the subsidised nature of the agro-industrial complex development remains the key problem of building a single ecosystem based on the dominant role of the agricultural products market. According to the Review of the agricultural market, the decisive factor behind the growth in the competitiveness of this complex is state support. The data from Rosstat suggests that state subsidies have formed 75% of the agricultural companies’ profits over the past four years. The subsidies remain a vital factor in making investment decisions in the agricultural sector.

Obviously, the chemical industry affects positively the growth of crop production, but a critically important factor in the national economic system development is the integration of agricultural engineering into a single system of technological standards of the agro-industrial complex. The competitive advantage of the country’s agriculture can be gained by reducing the cost of growing and harvesting, increasing productivity by automating these processes. The demand for automation will contribute to the emergence of new production facilities nationally focused on meeting the needs of agricultural producers by offering innovative solutions. Enterprises of the military-industrial complex with high scientific potential and experience in transferring technological solutions to civilian engineering can act as innovators.

Accordingly, the agriculture development will be promoted primarily by the related high-tech industries, which, on the one hand, will increase the contribution of agriculture to GDP, and on the other hand, will become an independent significant source of GDP growth in the country. These include the development and production of modern high-tech agricultural machinery with elements of robotics; the creation of integrated satellite geographic information, navigation and telecommunications services; the integration and development of new-generation software products and materials for remote sensing of the Earth and unmanned vehicles; the construction of modern agricultural infrastructure with control and management based on artificial intelligence; the development of information infrastructure in rural areas; creation of technologies and platforms to support decision-making by agricultural producers, etc.

Following the ecosystem approach will allow creating a sector parallel to the raw materials economy, which will not only become one of the world leaders, but also act as a multiplier of high-tech industries in the Russian economy.
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