

Digitalization of Agricultural Industry – the Vector of Strategic Development of Agro-industrial Regions in Russia

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Abstract

Today the strategic vector of agricultural development is connected with the introduction of digital technologies. Digitalization leads not only to transformation of production processes in the industry but as well has much wider environmental, social and institutional context. This paper is aimed at finding out what digital transformations have the most strategic significance for social and economic development of agro-industrial regions of the south of Russia, as well as at revealing the factors fostering or constraining these processes. Digital transformation in the south Russian regions has just affected the first level – application of new information technologies for raising economic performance and simultaneous alleviating environmental problems. The perspectives of digitalization of the agriculture are connected with developing open collaborative systems with different types of business collaborations. The authors highlight the main problems of realizing digital transformations in the agriculture of the south regions solving of which can be provided by means of authorities' institutional decisions within regional strategies of digitalization. This research gives an idea of the potential of agricultural digitalization and its results can be used for forming theoretical and methodological grounds for strategic development of agriculture in agro-industrial regions in modern circumstances.

Keywords

Digitalization, economic performance, agro-ecological systems, agro-industrial regions, regional development.

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Introduction

Digitalization is an important factor of modernizing agricultural production and providing its competitiveness in the world market. Nowadays the main prerequisites for developing digital processes in agriculture such as complicating logistics systems, the necessity of renewing out-of-date material and technical base, general greening of production processes have been formed. The pandemic COVID-19 that required to transfer some business processes to online mode even strengthened this trend and led to the actual absence of any alternative

to the process of transferring to digital technologies even in the most inert agricultural industries with the lowest demand for advanced technologies among the sectors of economy.

The process of AIC digitalization (AIC digitalization) is especially actual for agro-industrial regions of the South of Russia. Digital transformations will foster the increase in labour productivity, cropping capacity and etc. Digital technologies are the key determinant of the transferring to the new technological mode in AIC (Maksimova and Zhdanova, 2018). As it was highlighted in the research of the

cooperation project «German and Russian agro-political dialogue», the potential of digitalization implies reducing conflicts of aims at using lands as the production factor¹.

It is important not only to implement «smart» technics, but as well to maximally realize digitalization opportunities in agriculture for using economic and social potential of the region to the most extent. Digitalization of the agriculture leads not only to transformation of the production processes in AIC but as well has much wider environmental, social and institutional context. This paper is aimed at finding out what digital transformations have the most strategic significance for social and economic development of agro-industrial regions of the south of Russia, as well as at revealing the factors fostering or constraining these processes. The hypothesis of this research implies that digital transformations in agriculture not only favour innovative development of the industry but as well have strategic meaning for social and economic development of the region.

So far the term “digitalization” has had “vague” meaning. Some authors both in academic and business environments trying to learn the essence of the notion “digitalization” embrace a large variety of different phenomena and processes.

In international handbooks on statistical measuring of the level of digitalization of industries, this notion is understood as the process of introducing digital resources for solving different problems. In the world review of realization of the conception “Industry 4.0” for 2016 digitalization is defined as vertical integration of business models in one organization implying introduction of digital technologies at all stages: development, procurement, production, logistics and service². The term “digitalization” is defined by many researchers in their papers within the conception “Industry 4.0” For instance, C. Hopmann and M. Schmitz describe digitalization as successive application of “digital” methods and instruments during the whole process of development and production of the product including planning and quality management (Hopmann and Schmitz, 2020). T. Jeske, M. Würfels and F. Lennings represent digitalization as the process

of introducing artificial intelligence, methods of data and information management as well as improving personnel qualification due to advances in production technologies (Jeske, Würfels and Lennings, 2021).

Process approach to the research of digital transformations in the economy is reflected in papers of the Russian scientists. Thus, for instance, T. Judina defines digitalization as the process of transferring from robotic automation to the new production based on introduction of digital technologies leading to digital capital expansion (Judina, 2018). V. Tsirenschikov also defines digitalization as on-going process of implementing digital technologies in different spheres of activity (Tsirenschikov, 2019).

The researchers of the digitalization processes within the conception “Industry 4.0” assign a leading role in their development to technologies of high-speed data transmission, Internet-technologies highlighting technological aspects of this process. For instance, L. Geris, T. Lambrechts et al. define digitalization as a combination of processes of automatization, informatization, exchange of technologies using “digital twins” – digital presentation of a product or a process which is used for projecting optimization (Geris, Lambrechts, Carlier and Papantoniou, 2018).

However, over the last years an increasing number of scientists pay attention not only to technological but to social and economic aspects of digitalization, for instance, T. Pschybilla, A. Homann highlight that digitalization implies not only technological development of a company but its overall transformation including changes in hierarchical structures and personnel’s behavior as well as presenting and exchange of information (Pschybilla and Homann, 2020).

T. Mirolyubova et al. determining indices of digital economy include in it the whole complex of relations formed at using digital technologies in the system of production, distribution, exchange and consumption of tangible and intangible goods (Mirolyubova, Karlina and Nikolaev, 2020). This approach enables to pay attention to the necessity of interconnected functioning of technological, economic and social subsystems where managing information is the key determinant creating value of the whole system.

In researches of digitalization processes in agriculture ecosystem approach prevails.

¹ Digitalization of agricultural production in Russia from 2018 to 2025. https://agrardialog.ru/files/prints/apd_studie_2018_russisch_fertig_formatiert.pdf

² PwC Global Digital IQ. https://www.pwc.ru/ru/technology/assets/global_industry-2016_rus.pdf.

For instance, Z. Kapelyuk, A. Aletdinova pay attention to the fact that in order to provide sustainable development of agricultural enterprises it is necessary to maintain bio-productivity of ecosystems; and existing intensive technologies are not enough; it is necessary to provide active use of digital solutions (Kapelyuk and Aletdinova, 2017). O. Kolomyts and I. Ivanova consider creating digital agro-food ecosystems as the vector of strategic development of agricultural areas (Kolomyts and Ivanova, 2020). Ashlee-Ann E. Pigford et al. have similar views and to their perspective digital agro-innovative ecosystems will foster transferring to sustainable development (Pigford, Hickey and Klerkx, 2018).

The role of digital technologies in developing ecosystem services in food chains are subject to investigation by A. Lajoie-O'Malley, K. Bronson et al., J. A. Wilhelm, R. G. Smith et al., who pay particular attention to the necessity of taking into consideration environmental consequences of digitalization projects realization. In particular studying insiders' perception of ecosystem consequences can become a determining factor in creating the strategy of land utilization and developing policy of agricultural production expansion (Lajoie-O'Malley, Bronson, Van der Burg and Klerkx, 2020; Wilhelm, Smith, Jolejole-Foreman and Hurley, 2020). N. Roux, T. Kastner et al. also put emphasis upon the impact of agriculture on the state of land ecosystems (Roux, Kastner, Erb and Haberl, 2021).

P. Phillips, G. Jobe et al. consider that introduction of new hardware facilities, applications for big data processing, software and other digital technologies by the farmers leads to the transformation of structures not only common for agricultural production but in related sectors as well (Phillips, Relf-Eckstein, Jobe and Wixted, 2019). In this sense the perspectives of digitalization of agriculture can be considered by means of ecosystem approach. Thus, D. C. Rose, J. Chilvers offer to approach digitalization from wider mapping of ecosystem aimed at revealing the spheres of potential cooperation generating new valuable opportunities (Rose and Chilvers, 2018). Investment in science-based-innovative technologies is a must to bring about improved livelihoods of farmers and their families by producing more and higher quality crops for national population; enhanced nutritional value and safety of food to improve the health and well-being of people; and agricultural sustainability through efficient resource use (Alaverdyan et al., 2015).

Agro-ecosystems have significant impact on social and economic development of the region, however there are different points of view concerning the character of their influence. The role of agriculture is obviously reflected not only in its contribution to the GDP but in the complex relationships how it influences the life of rural areas (Nagy-Káposzta, 2016). Some researchers consider that anticipated effects of digitalization of agriculture can include: creating additional jobs, increasing labour productivity, generating knowledge-based economy (Matthess and Kunkel, 2020). However, there is an opposing opinion according to which digital technologies are considered as a destructive factor for social and economic potential of a region, as a source of new problems related to labour, finances and etc. rather than a problem solving facility (Abbasabadi and Soleimani, 2021; Bundy, 2017). For instance, members of Via Campesina consider that introduction of digital technologies will lead to release of labour executing non-qualified work in agricultural sector. It can affect the level of unemployment in agro-industrial regions where agriculture has always provided most employment opportunities absorbing more employees³.

Researching the factors determining directions of digital transformations in agriculture K. Rijswijk, L. Klerkx, J. A. Turner highlight that the level of digitalization of agricultural enterprises in the regions is mostly determined by the agricultural producers' understanding of their own place in regional production systems. According to the researches of these authors most of agricultural producers interpret digitalization as a process oriented at developing enterprise's internal environment rather than strategic changes of the role of agriculture in regional economic system. We consider that this interpretation of digital processes leads to digital transformations of targeted character that makes it impossible to create single regional digital landscape (Rijswijk, Klerkx and Turner, 2019).

This review enables to highlight a number of different factors determining effectiveness of realizing digital transformations in agriculture as well as to understand their role in social and economic development of a region. The authors of the paper suggest to understand digitalization of agricultural production as the process of making strategic decisions aimed at decreasing the extent of dependence of the production outcomes

³ La via Campesina policy documents 5th Conference. Mozambique, 16th to 23rd October 2008. <https://viacampesina.org/en/wp-content/uploads/sites/2/2010/03/BOOKLET-EN-FINAL-min.pdf>.

on environmental and climatic as well as anthropogenic factors by means of optimal production models generated by artificial intelligence on the basis of the data obtained by it as a result of fulfilling tactical tasks of production management (Mitrofanova, Chernova, Buyanova, Ivanov et al., 2019; Shelkovnikov, Petukhova and Alekseev, 2020).

Materials and methods

The research of the impact of digital transformations in agriculture on regional development should be started with considering what particular economic problems are taken into account at developing such projects. It will enable not only to estimate digitalization effects for agricultural enterprises themselves but to determine their contribution in fulfilling strategic challenges of social and economic development of the region. The main research issues were formulated as follows: what digital technologies are used in agriculture and what challenges are fulfilled with their help in the south regions of Russia; what perspectives and opportunities can be obtained by means of using digital technologies in agriculture for fulfilling strategic tasks of regional development?

Hence this research consists of the following major stages. The first stage implies determining main directions of developing digital technologies in agriculture. On the basis of literature review devoted to the subject under consideration digital technologies in agriculture are examined from the perspective of solving problems of economic development. The second stage implies consideration of the scenario of digital transformation of agriculture in agro-industrial regions of the south of Russia. Our review supposes revealing peculiarities of digitalization processes in these regions, considering the impact of the outcomes of these processes on social and economic potential of the area. The third stage implies drawing conclusions if taken measures aimed at digitalization of agriculture correspond to strategic goals of regional development. At these stage the factors and conditions for expansion of benefits from digitalization for the economy of the region are revealed.

The authors have applied a combination of methods including methods of descriptive statistics, review of the related researches reflecting application of digital technologies in agriculture. It is necessary

to note that this research is aimed at generalization of potential opportunities of using digital technologies for meeting strategic goals of social and economic development of agro-industrial regions rather than analyzing practical usage of particular digital technologies in agriculture.

The study subject is represented by the south regions of Russia: Krasnodar Region, Rostov and Volgograd Regions having agro-industrial specialization (AIC is in the 2nd place as a contributor to GRP). The choice of these regions is determined by their significant contribution to producing agricultural goods in Russia. In terms of the key agricultural indices Krasnodar region is in the 1st place, Rostov Region – in the 2nd place, Volgograd Region – in the 9th place. The information base of the research is represented by Rosstat (Russian Federal State Statistics Service) data, reports of the Ministry of Agriculture of the RF on realization of the program “Digital Agriculture” as well as official data allocated on the sites of regional and municipal authorities of the areas under examination as well as data of rating agencies.

Results and discussion

Digital transformation in agriculture: sources and directions of value creation

Intensive development of digital technologies in Russian agricultural production started since signing the Edict of the President of the Russian Federation No. 204 “On National Goals and Strategic Challenges of Development of the Russian Federation for the period up to 2024”⁴, which set the goal of transforming priority industries of the economy including agriculture by means of introducing digital technologies platform solutions. Within realization of this goal the industry-related project “Digital Agriculture” was developed with time frame 2019–2024⁵.

At the beginning of the project realization Russia took very low positions on the level of digitalization of agriculture – the last place among European countries, the Republic of Korea,

⁴ Edict of the President of the Russian Federation from 07.05.2018 No. 204 “On National Goals and Strategic Challenges of Development of the Russian Federation for the period up to 2024”. <http://publication.pravo.gov.ru/Document/View/0001201805070038>.

⁵ Industry-related project “Digital Agriculture”: official addition . Moscow, “Rosinformagrotech” Publ., 2019. 48 c. <https://mcsx.gov.ru/upload/iblock/900/900863fae06c026826a9ee43e124d058.pdf>.

Turkey and Japan⁶. It's probably caused by the fact that during industrial development (till the end of 20th century) it was commonly accepted that strategically important directions of agro-industrial complex should be determined by internal goals and objectives of the industry rather than dictated by other industries and sectors of economy (Toguzayev, Toguzayev and Modebadze, 2020). Along with it the national agriculture has always been characterized by its low investment attractiveness due to long production cycle and high natural and climatic risks.

However, development of the “digital era” couldn't leave untouched many processes in the sphere of AIC. Understanding of the necessity of digitalization in agriculture is determined by its significant lack behind Western Europe, Canada, the USA, Australia, China on indices of labour productivity, cropping yield, and others. Digitalization is supposed to enable to make a significant technological breakthrough in the sphere of AIC. However nowadays development of the digitalization processes in Russian agriculture can be characterized as “tactics of quick victories” according to which some elements of digital economy are implemented only where they are mostly required and at that they have the shortest pay-back period: satellite positioning of farm machinery and equipment; quality monitoring of executed works; resources accounting and control; control over animals' state; crop harvesting automation and etc.

Digitalization of agriculture in regions of Russia tends to move towards provision of agricultural productions with navigation systems as well as automation of organizational and managerial processes and cross-industry interactions. In countries leading in the agricultural market digital technologies robotize production, expand the range of big data application. At that digitalization of agriculture changes the whole regional landscape creating new business, economic, institutional mechanisms of development.

The estimation of the possible impact of digitalization of agriculture and forming agro-ecosystems on strategic development of the economy of the region should start with considering

⁶ Digital Transformation of Industries: Starting Conditions and Priorities: Reports to XXII April International Scientific Conference on Problems of Developing Economy and Society. Moscow, “Higher School of Economy” Publ., 2021. 239 p. https://www.researchgate.net/publication/351035378_Cifrovaia_transformacia_otraslej_startovye_uslovia_i_prioritety.

what objectives were supposed to be fulfilled by means of using digital technologies in agriculture (Table 1).

Objectives fulfilled	Digital technologies
Increasing productivity of agricultural production using less fertilizers and with less environmental pollution	Geo-information monitoring systems of soils state, ecological situation. Remotely piloted vehicles. Maintaining optimal conditions for life organisms habitat, growth of plants in automated mode.
Information asymmetry related to agricultural production: financial services, marketing, access to production markets and etc.	Market places for marketing and selling agricultural production to small enterprises. Instruments for raising digital literacy
Minimizing errors in complex production processes by means of interaction model “live organism – technical systems”	Using neuro-technologies and artificial intelligence for seeds choice and selection
Raising economic efficiency of agricultural production	Agricultural machinery sharing based on digital platforms. Using remotely piloted vehicles for seeds planting
Distant management. Raising control and management coverage of agricultural arrears	Geo-information systems of growth monitoring of crops by means of satellite systems, early disease detection of plants. Irrigation management
Managing finances and monitoring commercial transactions	Digital solutions in logistics. Sales monitoring systems. Smart-contracts.

Source: Own processing

Table 1: Objectives of agricultural production fulfilled by means of using digital technologies in Russia.

On the basis of the presented data it can be assumed that digitalization of agriculture in Russia applies innovations as the source of economic growth. It means that any technological perspective can be interpreted within the question of reasonability of using this or that advanced technology in agricultural system. The main desired result of expanding digitalization processes in agriculture is providing profitability and sustainability of production systems development (Gaál, Molnár, Illés, Kiss, Lámfalusi and Kemény, 2021), raising market value of the company which in many respects is determined by digital assets. It can be proved in particular by the indices estimating the level of digitalization of AIC in regions

developed by the Ministry of agriculture of the RF: testing pilot solutions and their replication, full service application of digital government and new digital technologies, introduction of amendments to normative acts providing realization of the industry project “Digital agriculture”, unifying and application of centralized decisions as well as having an opportunity switching to the existing regional systems with high level of development of IT technologies in agriculture⁷. This orientation significantly distracts researchers from opportunities of fulfilling tasks of digital development of agriculture as an agro-ecosystem whereas processes of agriculture digitalization can significantly change public face of agro-industrial regions transforming not only their agricultural systems but as well the whole regional landscape. Besides digitalization can make agriculture attractive for the youth at the same time stimulating demographic renewing of agricultural arrears.

Agricultural biodiversity, landscapes, the range of services which can be provided by agro-ecosystem are in many ways connected with measures of regional management of agriculture digitalization processes (Shah, Liu, Yang, Wang, Casazza et al., 2019). That is why further we are going to consider how agriculture digitalization opportunities are realized in practice of regional strategic planning of the south agro-industrial regions of Russia.

⁷ Expanded Review of Development of Agricultural Digitalization in the RF. State and Perspectives. As of April-May 2020. https://agrardialog.ru/files/prints/rasshirenniy_obzor_razvitiya_tsifrovizatsii_selskogo_hozyaystva_v_rf_aprel_may_2020.pdf.

Trends of digital transformations in agriculture (by the example of agro-industrial regions of the south of Russia)

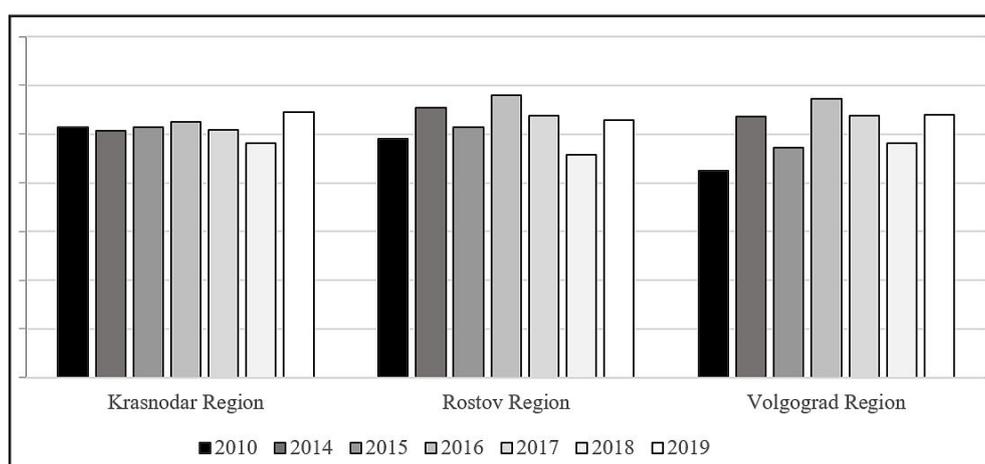
In order to highlight and think over the main trends of development of digital processes in agriculture of agro-industrial regions of the south of Russia, conceptualize links related to the consequences of digitalization firstly let us characterize the present state of this sector in the regions under examination.

Agriculture has a significant role for Krasnodar, Rostov and Volgograd Regions. The share of this sector of economy in GRP makes up slightly over 10 percent.

As it can be seen from the Figure 1 agriculture of Krasnodar Region is developing relatively stable whereas Rostov and Volgograd Regions are distinguished by unstable character of development of agricultural productions.

Growth indices of crop production in the areas are more changeable than growth indices of animal production (Figure 2, 3) that is caused by higher sensitivity of this sector to natural and climatic factors. Simultaneously we can note that in Rostov Region there is a trend to decreasing animal production.

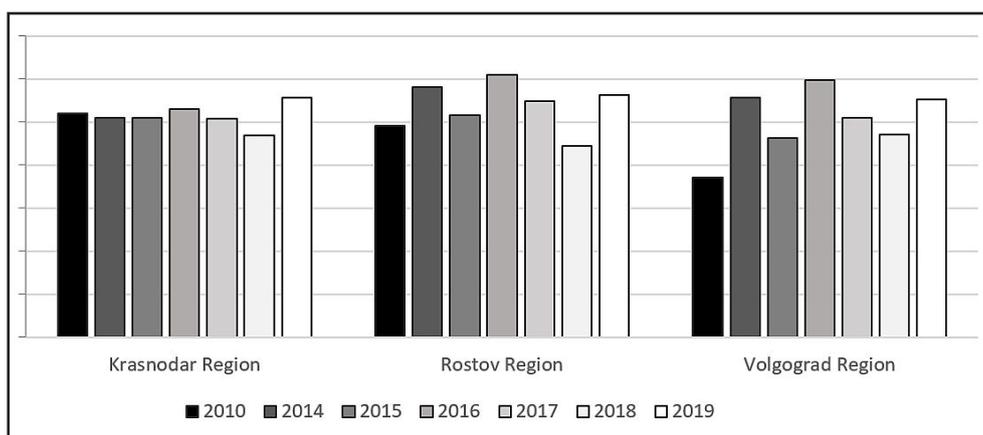
Development of the agricultural production is connected with solving problems of import substitution (Mitrofanova, Buyanova, Chernova, Ivanov et al., 2019) and increasing export of agricultural production that is provided by means



Source: Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, “Rosstat” Publ., 2020. 1242 p.

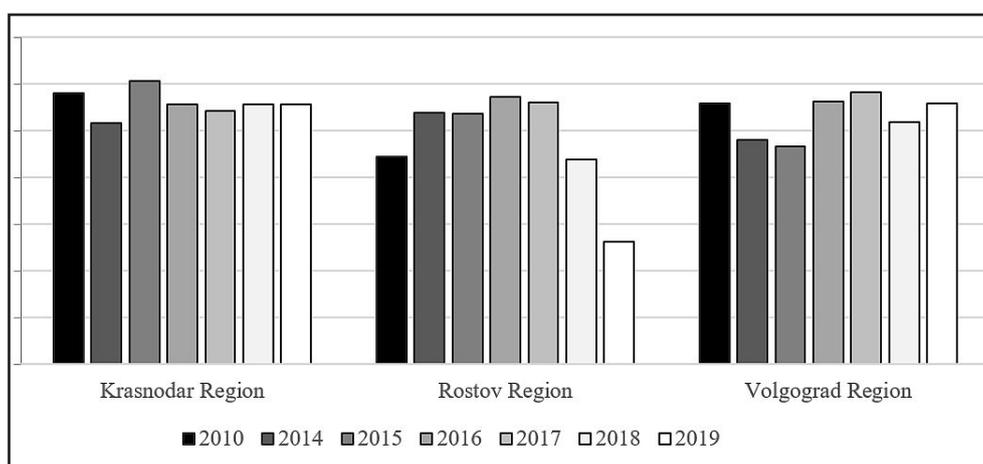
https://rosstat.gov.ru/storage/mediabank/LkooETqG/Region_Pokaz_2020.pdf.

Figure 1: Indices of agricultural production in agro-industrial regions of the South of Russia, as a percentage over the previous year.



Source: Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, “Rosstat” Publ., 2020. 1242 p. https://rosstat.gov.ru/storage/mediabank/LkooETqG/Region_Pokaz_2020.pdf.

Figure 2: Crop production in agro-industrial regions of the South of Russia, as a percentage over the previous year.



Source: Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, “Rosstat” Publ., 2020. 1242 p. https://rosstat.gov.ru/storage/mediabank/LkooETqG/Region_Pokaz_2020.pdf.

Figure 3: Animal production in agro-industrial regions of the South of Russia, as a percentage over the previous year.

of increasing areas under crops (Figure 4), as well as increasing crop productivity (Figure 5).

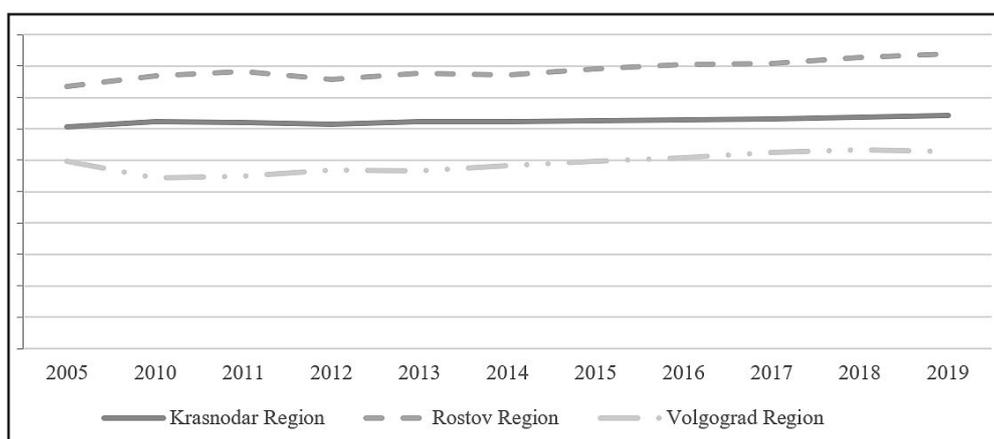
The structure of agriculture in the regions is represented by agricultural organizations of different sizes. Among the largest agro-industrial holding in the South of Russia there are the following: “Jug Rusi”, “Aston”, “Agrocomplex”, “Step”, “Kuban”, which accumulate over two thirds of revenues in Russian AIC. However the most agro-holdings’ revenue is generated trading oil products, gas and liquid fuels and etc⁸.

Peasant (farm) households cover 30-40%

⁸ Expert-Jug. News and Business Practice. <https://expertsouth.ru/main/top-5-krupneyshikh-agropromyshlennykh-kholdingov-yuga-rossii/>.

of agricultural production. Low-technology production prevails on most farms. Agricultural enterprises widely use non-qualified labour. The share of the employed in agricultural production makes up 11–13% (the second place after trade).

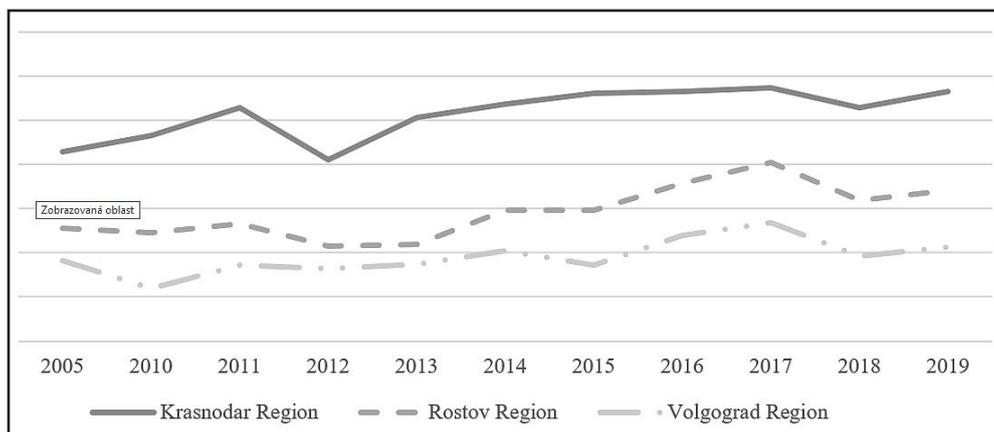
Profitability of sold goods and products of agricultural organizations is represented on Figure 6. Farmers, small and medium-size enterprises experience the most difficult financial state. It is mostly caused by the problems connected with selling their products: working with wholesalers is considered to be disadvantageous and designing trading places implies significant costs related to renting trading places, undergoing control and paying the salary to the seller.



Source: Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, “Rosstat” Publ., 2020. 1242 p.

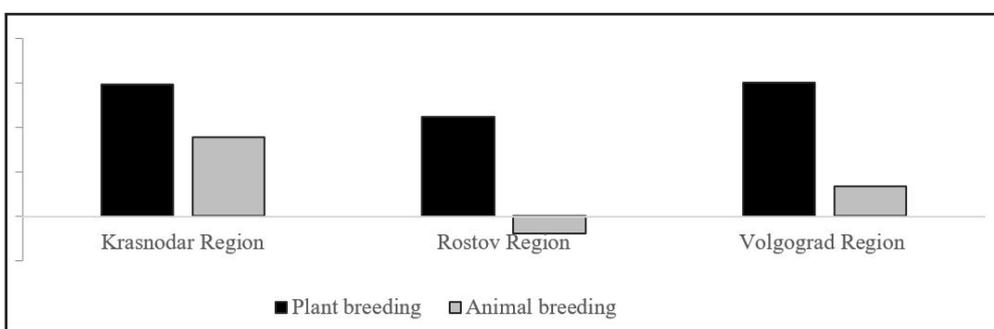
https://rosstat.gov.ru/storage/mediabank/LkooETqG/Region_Pokaz_2020.pdf

Figure 4: Areas under crops in agro-industrial regions of the South of Russia, as a percentage over the previous year, tsd. hectare.



Source: Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, “Rosstat” Publ., 2020. 1242 p. https://rosstat.gov.ru/storage/mediabank/LkooETqG/Region_Pokaz_2020.pdf

Figure 5: Productivity of grains and grain legumes in agro-industrial regions of the South of Russia, as a percentage over the previous year, centner per hectare.



Source: Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, “Rosstat” Publ., 2020. 1242

Figure 6: Profitability of sold goods and products of agricultural organizations in agro-industrial regions of the South of Russia, %

The degree of depreciation of the main assets in agriculture makes up in Rostov Region 46,3% (including completely depreciated ones -13,4%), in Krasnodar Region 44% (including completely depreciated ones -12,4%), in Volgograd Region 34,1% (including completely depreciated ones -8,5%)⁹.

According to the expert reviews digital technologies have been introduced up to 5% of households. The most popular digital technology in agriculture is navigating agricultural machinery, inventory, monitoring executed works by means of cheap GPS-detectors that is why it was applied in many agricultural enterprises. Agro-holdings are considering the perspective of digitalization trying to assess economic effect of digitalization of all stages of agricultural production.

In plant breeding segment digitalization implies using satellite technologies for monitoring the state of cultivated lands, transport vehicles, parallel driving as well as differentiated spraying of weeds, crops, fertilizing and irrigating. At that these technologies cover up to 10% of lands under crops. Decisions of using precision agriculture are made in less than 3% of farms¹⁰. For comparison in countries of the European Union this index reaches 80%¹¹.

In animal farming the elements of precision breeding are used for monitoring the state of health of the flock and individual species as well as for monitoring the quality of animal production, and the digital data bases of production processes are formed.

Estimating the first results of digital transformations in agriculture of the regions of the South of Russia there can be highlighted two main models of development of these processes.

1. «Entrepreneurial startup» Integration of software and digital analytics into customer packet of services. Many entrepreneurs use those digital technologies that solve particular problems of their agricultural production This model is typical for small and medium-sized enterprises.

2. «Corporative model» Digital innovations are combined with modernization of material resources and technology. The example of such model is an integration of large agro-holding with world producers of agricultural machinery for mutual usage of digital opportunities.

Regardless of the model of digital processes development digital transformations in agriculture of the south Russian regions are initiated from the top downwards within realization of industry projects and taking measures as a response to authorities' requirements for environmental protection. Internal factors determined by anticipating financial benefit or caused by the trust to digital transformations as a source of economic development do not appear to be a significant driving force.

Responses to digitalization can be described as preliminary as it has not become a core component of organization development and value creating basis yet.

Both business and regional authorities interpret digital agriculture in the context of problems faced by domestic agriculture. That is why realized digitalization projects tend to have a targeted character and imply modernization changes for a particular enterprise aimed at raising its productivity.

The consequences of digitalization of a particular production are not considered in relation to other participants of the value creating chain neither agricultural producers nor regional authorities. As a result, we can observe different rates of changes in agricultural sector throwing no light on perspectives of industry development as a whole. Such approach creates a new challenge of managing mixed agricultural production at the regional level.

Only some large agro-holdings perceive digitalization strategically. The main implemented changes are connected with automation of managerial processes and interactions with state authorities. In other words most agricultural producers don't make any radical decisions related to digitalization, instead of it they continue to use traditional approaches and technologies.

Results and discussion

Ineffective development of agriculture endangers not only nature protection goals but as well existing chains of distributing agricultural production which

⁹ Regions of Russia. Social and Economic Indices. 2020: Statistical Digest. Moscow, "Rosstat" Publ., 2020. 1242 p. https://rosstat.gov.ru/storage/mediabank/LkooETqG/Region_Pokaz_2020.pdf.

¹⁰ Digital Transformation of Agriculture in Russia. Moscow, "Rosinformagrotech" Publ., 2019. 80 p. <https://mcx.gov.ru/upload/iblock/28f/28f56de9c3d40234dbdcfbac94787558.pdf>.

¹¹ Digitalization of Agriculture in Russia: stages, outcomes, plans. Geomet. <https://gpsgeometer.ru/blog/tsifrovizatsiya-selskogo-hozyajstva-v-rossii-etapy-itogi-plany>.

determine sustainability of social and economic development of the area. However, the main threat to agricultural development is local competition for land labor, and capital demonstrated by other more effective sectors rather than foreign agricultural producers (Phillips, Relf-Eckstein, Jobe and Wixted, 2019). Digital technologies enable agricultural enterprises to use new valuable opportunities.

However, in spite of multiple scientific proofs of social, economic and environmental benefits of digitalization introducing these processes in agricultural practice is still the central challenge of south Russian agro-industrial regions. Digitalization indices reflect social and economic practice of mixed economy established in the regions. At the present stage digital transformation of agriculture in the south Russian regions has affected the first layer – implementing new technologies for solving problems of economic productivity and simultaneous reduction of environmental problems.

The logical consequence of further introduction of digital technologies is forming open collaborative systems where all insiders will be able to choose business partners (Day and Sigrimis, 2020). In the world practice in particular the following forms of business interactions in the sphere of digitalization of agriculture has become commonly used: digital packet transactions related to the development of new forms of insurance for farmers from climatic risks; sharing land resources (agro-forest-melioration) for expanding forests on tillable lands aimed at preventing dust-storms sweeping out soil layer; creating digital ecosystem for all regional market insiders: transport and logistics companies, agricultural machinery, mechanization and fertilizers production related trade.

Expanding the sphere of applying digital technologies in the regions will foster forming agro-ecosystems as a complex of eco-system services taking into account production systems in which they are supposed to be integrated. The directions of agro-ecosystems development mostly depend on regional authorities understanding of their place in regional development. The standardized range of indices of ecosystem services providing includes: 1) biomass production; 2) refilling underground waters, 3) carbon storage; 4) generating the habitat for agricultural bio-diversity; 5) creating landscape attractiveness; 6) soil preservation (Ungaro, Schwartz and Piorr, 2021). Along with these direct ecosystem services some indirect ones can

be provided as well including regulating climate, agro-tourism, recreation, cultural and educational values (Shah, Liu, Yang, Wang et al., 2019).

Thus digitalization leads to the necessity of expanding cooperation: involving new partners, developing new forms of interaction, providing new kinds of services. However meeting these objectives is related to a number of problems:

- non-structured collaborative environment due to large share of shade sector of economy in AIC which is not ready to provide data revealing its performance;
- differences in perception of the value of economic effects of digitalization of agriculture by different economic agents;
- agricultural producers' orientation at production rather than sustainable development of regional ecosystem;
- the absence of motivation to realize digital projects on the part of agricultural producers;
- lack of funds experienced by small and medium-sized business and farmers necessary for realizing digitalization projects; for instance, a medium-sized farm needs 1 million rubles per year for introducing the technology of satellite monitoring;
- lack of agricultural personnel with digital competences;
- digital inequality between city and village related to the Internet access and level of digital literacy of population.

The opportunity of solving these problems is mostly determined by institutional decisions of regional authorities. For instance, developing of sharing economy can become an institutional decision fostering digitalization of small farms. In particular sharing agricultural machinery is actively experienced in Germany among small groups of farmers having close social relations. According to Nigeria and India's practice subcontractors possessing agricultural machinery and providing it to several farmers can gain more benefits using GPS-devices and software (Daum, Mayienga, Villalba, Kayode et al., 2020).

Thus, effective development of digitalization processes in agriculture of the South of Russia requires regional strategy of digitalization with assessment of obtained benefits and possible problems.

Analyzing activity of regional authorities in the sphere of digitalization it can be observed that its main directions are connected with realization of the industry project “Digital Agriculture” which at the first stage implies digital land inventory and introducing e-document flow (Mitrofanova, Chernova, Buyanova, Ivanov et al., 2019; Mitrofanova, Chernova and Patrakeeva, 2020). Realization of this program is supposed to enable application of the system of digital automation in agricultural production represented by “Smart Farm”, “Smart Field”, “Smart Greenhouse” and etc.

To our perspective regional strategies of agriculture digitalization must not only focus on technological aspects of industry program realization but as well give answers to the following questions principally important for social and economic development of the region:

- how to use digitalization processes for creating new jobs in rural areas including high-qualified ones;
- what institutional and technological decisions are required for providing participation of small and medium-sized agricultural producers and farmers in the processes of digitalization;
- what potential does digitalization have for raising ecological, tourist and recreational potential of the region;
- how can be assessed the consequences of digitalization for population, how can it influence standard and quality of life, incomes;
- how can the potential of financing of digitalization processes be assessed for different groups of agricultural producers.

Concurrently the system of regional control over the processes of digitalization in agriculture should provide integration of efforts of a large number of different actors: agricultural producers, suppliers of agricultural machinery, knowledge, environmental innovations. Coordination of digital models of developing of agricultural enterprises at the regional level would enable the following: 1) to prevent inequality in agricultural sector

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by means of involving all insiders; 2) to provide compromise between agricultural products and services: for instance, animal breeding (pastures) – soil preservation; plant breeding – carbon storage (Zhong, Wang, Zhang and Ying, 2020; Vishnevskiy, Gokhberg, Dementjev, Dranev et al., 2021).

Conclusion

Social and economic consequences of digitalization in agriculture for regional development have been rarely discussed although such analysis can give information important to regional policy. In the whole this research gives idea of the digitalization potential in agriculture. As the result of the research the authors’ hypothesis that digital transformations of agriculture not only help to fulfill goals of innovative development of the industry but as well have strategic significance for social and economic development of the region has been proved. Digitalization is anticipated to lead to the productivity growth, increasing cropping yield, producing green goods, decreasing negative environmental effect. Many researchers highlight its impact on employment. However these issues require further examination since the absence of objectiveness can negatively influence regional policy.

It is necessary to note that abilities of getting benefit can differ depending on the level of development of agricultural production in the regions, for instance among developed and developing agricultural productions. That is why further researches will help to verify empirically conclusions made by authors.

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