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**Elena V. Sofiina**[1]

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# MODERN SYSTEMWIDE PROCESSES OF QUALITY MANAGEMENT IN AGRICULTURAL TENURE AT THE REGIONAL LEVEL

***Abstract:*** *This paper is aimed at identifying the key quality factors of agricultural products in contemporary Russia and developing recommendations for managing these factors in the interests of improving the quality of products under consideration and promoting the development of agriculture at the regional level (through the example of the Kirov Region). The research is carried out in two consecutive stages. At the first stage, all-Russian data are used due to insufficient detail of regional statistics. The method of regression analysis is used for determining the dependence of quality indicators on potential factors. Then, the simplex method is used to determine the values that are expected to be taken by the factor variables so that the target values could be achieved by the response variables. As a result, the arithmetic means of the factor variables are determined and the values that will be taken by the response variables in this case are calculated; the increment in the values of all variables compared to 2018 is analyzed. At the second stage, the results obtained, conclusions drawn and recommendations made are tested through the example of the Kirov Region of Russia – a qualitative analysis of land use processes in the region is performed. As a result of the research, the key quality factors of agricultural products (horticulture) in Russia have been substantiated, recommendations were made, and limitations of managing them in the interests of improving the quality were specified.*

***Keywords:*** *Auality control; Product quality; Agriculture; Regional economy; Russia*

## 1. Introduction

Since the collapse of the USSR the areas of used agricultural lands in Russia have been significantly reduced. Since 1990 crop areas have been declined by 37.86 million hectares. Currently, there are 35.2 million hectares of underutilized lands (plowed fields) and 4.4 million hectares of abandoned (fallow) ones. Large areas of idle and unused agricultural lands are an integrated index of the social and economic origin of these processes; besides, agricultural production is caused by unfavorable agricultural climatic conditions and, as a result, low profitability of crop industry (Ministry of Agriculture of Russia, 2020). Negative processes in the agro-industrial complex at the regional level are withdrawal of lands and their non-use in agriculture, decrease of crop areas, and

[1]Corresponding author: Elena V. Sofiina
Email: evsofina@mail.ru

exhausting land tenure. Mentioned ones in the regional land tenure lead to an increase in the overall number of low-income families, low quality of life, migration outflows, degradation of human potential, disappearance of villages, unsuitable living conditions in rural areas and the outward flow of people therefrom.

The working hypothesis of this research is that the root cause of the described problem of contemporary Russia consists in the lack of quality of agricultural products, as well as in continued uncertainty about quality factors of these products and the resulting lack of formedness of methodological framework for quality control. This paper is aimed at identifying the key quality factors of agricultural products in contemporary Russia and developing recommendations for managing these factors in the interests of improving the quality of products under consideration and promoting the development of agriculture at the regional level (through the example of the Kirov Region).

## 2. Literature review

In particular, various issues related to measurement and control of quality of agricultural products and horticulture are addressed in numerous thematic research papers, which include works by Andronova (2019), Bannikova et al. (2019), Ivanov et al. (2019), Kassa (2017), Milovanović (2017), Pichkov (2016), Shokhnekh (2019), Urban and Toga (2017), Zavyalova et al. (2018).

In their paper, Jödicke et al. (2020) describe the impact of technological parameters on the quality of dried agricultural products (determined using the accumulated heat demand). Zappalaglio et al. (2020) provide geography-specific directions for the protection of agricultural products in the EU and raise the question of whether quality schemes are able to solve this problem. Mujdalipah and Tania (2019) point out the importance of technologies for improving the quality of agricultural products. The scholars provide recommendations for testing the abilities of students of educational institutions in the interests of improving the quality of processing of agricultural products through the development of a virtual laboratory as the solution to the problem of limited manufacturing capacities.

In their paper, Li et al. (2019) pursue a study of consumer classification and satisfaction with quality of agricultural products (based on block rfm-servqual model). Du et al. (2019) suggests that X-ray computed tomography be used for quality control of agricultural products. May et al. (2019) provides nano-methodological recommendations for assessing the impact of accumulated environmental damage on the quality of soil, surface and subsurface water, agricultural products as a result of the activities of a mining company.

In their paper, Liao and Xu (2019) provide rationalization for the system of traceability of agricultural products based on blockchain technology and control in tea safety management. Ran et al. (2019) offer a new method for producing chlorine dioxide and its mechanism of action for the removal of hazardous substances and preservation of qualitative indicators of agricultural products. Jin and Wang (2019) analyze the strategy of traceability of quality and safety of agricultural products.

The publication by Galstyan et al. (2019) presents modern approaches to storage and efficient processing of agricultural products for obtaining high-quality food products. Liu and Xia (2019) pursue their study and apply the blockchain technology to monitor quality of agricultural products. Cortés et al. (2019) have been developing the monitoring strategies for quality control of agricultural products with the use of visible short-range infrared spectroscopy. The study by El-Mesery et al. (2019) describes the use of non-destructive technologies for the quality control of agricultural and food products.

Wang (2019a) developed a model for merging big data of quality and safety of agricultural products based on blockchain technology. Wang (2019b) proposed using an AI integration method for the data on the quality of supply chain of agricultural products based on blockchain technology. The paper by Popkova et al. (2018) describes the shortcomings of the legislative framework for innovative activities in agriculture in contemporary Russia and the ways of removing them in the interests of improving the quality of agricultural products through the use of advanced technologies. Sukhodolov et al. (2018) present special aspects of the formation and development of the Internet economy in Russia and describe its impact on quality of agricultural products.

Ragulina and Bratarchuk (2019) point out the paramount importance of staffing for quality control of agricultural products. The scholars describe the conceptual problems of modern extended education in the agricultural sector and put forward HR strategies from employers. Ragulina and Zavalko (2019) developed a system of state support of the agricultural sector in the interests of improving the quality of products. Ali Kamil et al. (2019) substantiated special aspects of cooperation between the Russian Federation and African countries in the agricultural sector.

Thus, the review of literature on the selected topic has demonstrated that the issue of quality of agricultural products has been quite adequately addressed in the existing studies and publications. Nevertheless, the methodological issues of corporate quality control of agricultural products are still understudied. The regional aspect of product quality control in agriculture has received almost no attention by the researchers and has not been addressed in the available literature. Identified gaps define the field of further research into the quality control of agricultural products at the regional level.

## 3. Materials and method

The research is carried out in two consecutive stages. At the first stage, all-Russian data are used due to insufficient detail of regional statistics. The method of regression analysis is used for determining the dependence of quality indicators – marketability (saleability – in terms of categories of farms/households, including agricultural organizations, private households and peasant (private) farms, and the yield of potatoes and vegetables as the main crop products of Russia – on the following potential factors on which official statistical information is available:

- fixed investment as an indicator of modernization of equipment and technologies;
- the volume of simultaneous storage of potato, fruits and vegetables as an indicator of adequate supply of logistics services;
- tractor workload as an indicator of adequate supply of equipment;
- application of chemical fertilizers to crops;
- application of organic fertilizers to crops;
- chemical reclamation activities (liming of acid soils);
- irrigation water use;
- generating capacities per 100 hectares of crop area.

Since the official statistics from Rosstat contains the data for 2018 only, the authors of the paper have also used the forecasting data for the period from 2019 till 2024 for data updating and obtaining the most accurate results of the analysis. The models of multiple linear regression are made as follows: $y=a+b1*x1+\ldots+bn*xn$, where y is the dependent (response) variable, x is the independent (factor) variable, a is the persistent variable, b is the computed coefficient which shows to what depth y will change if x increases by 1. In addition, p-values are determined which demonstrate the accuracy of paired associations between indicators. If p-value does not exceed 0.05, the association between indicators is recognized as statistically significant at the level of significance α=0.05.

Then, the simplex method is used to determine the values that are expected to be taken by the factor variables so that the target values could be achieved by the response variables. For y1-y6, the target values are 100% (full marketability). For y7 and y8, the target values are values for 2024, that are expected to be taken by them in 2018, that is, in accordance with Table 1, we have the following: y7=219, y8=255. As a result, the arithmetic means of the factor variables are determined and the values that will be taken by the response variables in this case are calculated; the increment in the values of all variables compared to 2018 is analyzed.

At the second stage, the results obtained, conclusions drawn and recommendations made are tested through the example of the Kirov Region of Russia – a qualitative analysis of land use processes in the region is performed. The dynamic structure and availability of unused agricultural lands, as well as the lack of gross product for 2011-2016 in the Kirov Region are discussed. The dynamics of the use of agricultural lands, the structure of underutilized lands, the structure of types of gross crop product, the use of agricultural lands by individuals and communities, as well as the structure of usage of agricultural lands by individuals and communities in the Kirov Region for the period of 2011-2016. Based on this, the key deterrents on the way toward the development of agricultural sector in the Kirov Region from the perspective of product quality control are defined.

## 4. Results

### 4.1. System multi-factor quality analysis in agriculture in Russia

The official statistics of the marketability of potatoes and vegetables in Russia by categories of farming units in 2014-2018 according to Rosstat and the author's forecast for 2019-2024 are presented in Table 1.

**Table 1.** Statistics of the marketability of potatoes and vegetables in Russia by categories of farming units in 2014-2018 and the forecast for 2019-2024

| Year | | Marketability of agricultural products by categories of farming units, % | | | | | |
|---|---|---|---|---|---|---|---|
| | | Potatoes | | | Vegetables | | |
| | | AO | PH | PPF | AO | PH | PPF |
| | | $y_1$ | $y_2$ | $y_3$ | $y_4$ | $y_5$ | $y_6$ |
| 2014 | | 59.2 | 15.7 | 55.1 | 83.9 | 15.8 | 81.8 |
| 2015 | | 55.3 | 15.7 | 52.9 | 78.6 | 15.7 | 79.0 |
| 2016 | | 67.7 | 16.2 | 54.1 | 79.4 | 15.7 | 75.5 |
| 2017 | | 65.7 | 16.2 | 57.6 | 79.3 | 15.8 | 78.7 |
| 2018 | | 63.2 | 16.5 | 52.7 | 87.9 | 15.5 | 78.6 |
| 2019 | forecast | 60.8 | 16.8 | 48.2 | 97.4 | 15.2 | 81.8 |
| 2020 | | 58.5 | 17.1 | 44.1 | 108.0 | 14.9 | 85.2 |
| 2021 | | 56.3 | 17.4 | 40.4 | 119.7 | 14.6 | 88.7 |
| 2022 | | 54.1 | 17.8 | 36.9 | 132.7 | 14.4 | 92.3 |
| 2023 | | 52.1 | 18.1 | 33.8 | 147.1 | 14.1 | 96.1 |
| 2024 | | 50.1 | 18.4 | 30.9 | 163.0 | 13.8 | 100.1 |

The following notations are used in the Table:
AO – agricultural organizations;
PH – private households;
PPF – peasant (private) farms.
Source: compiled by the author based on information from Rosstat (2020).

As can be seen from Table 1, the overall marketability of vegetables is much higher than the marketability of potatoes. In agricultural organizations in 2018, it was 87.9% and, according to the forecasts, it will reach 100% (maximum value) by 2024, despite the fact that the “ceteris paribus” forecast assumes achieving 163%, which is impossible. The marketability of vegetables in private households in 2018 was 15.5% and, according to the forecasts, it will decrease to 13.8% by 2024. The marketability of vegetables in peasant (private) farms in 2018 was 78.6% and, according to the forecasts, it will reach 100% by 2024.

The marketability of potatoes in agricultural organizations in 2018 was 63.2% and, according to the forecasts, it will decrease to 50.1% by 2024. The marketability of potatoes in private households in 2018 was 16.5% and, according to the forecasts, it will reach 13.8% by 2024. The marketability of potatoes in peasant (private) farms in 2018 was 52.7% and, according to the forecasts, it will reach 30.9% by 2024.

Conspicuously, the marketability of private households is the lowest, which testifies not only that they are focused on satisfaction of in-house needs, but also that the quality of their crop products is the lowest. Statistics on the yield and potential quality factors of potatoes and vegetables in Russia in 2014-2018 according to Rosstat and the forecasts for 2019-2024 are presented in Table 2.

**Table 2.** Statistics on the yield and potential quality factors of potatoes and vegetables in Russia in 2014-2018 and the forecasts for 2019-2024

| Year | | Yield, hundred kilograms per hectare of harvested acreage | | Fixed investment, billion rubles | The volume of simultaneous storage of potato, fruits and vegetables, tons | Tractor workload, hectares | Application of chemical fertilizers to crops, million tons | Application of organic fertilizers to crops, million tons | Chemical reclamation activities (liming of acid soils), million hectares | Irrigation water use, million m3 | Generating capacities per 100 hectares of crop area, h.p. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Potatoes | Vegetables | | | | | | | | |
| | | $y_7$ | $y_8$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ |
| 2014 | | 153 | 219 | 282.6* | 779247* | 290 | 1.9 | 61.6 | 0.3 | 7141 | 201 |
| 2015 | | 164 | 226 | 304.7 | 676611* | 308 | 2.0 | 64.2 | 0.2 | 6785 | 197 |
| 2016 | | 158 | 229 | 379.8 | 587493* | 320 | 2.3 | 65.2 | 0.2 | 6709 | 200 |
| 2017 | | 163 | 241 | 400.5 | 510113 | 328 | 2.5 | 66.6 | 0.2 | 6717 | 198 |
| 2018 | | 170 | 243 | 431.8 | 442925 | 337 | 2.5 | 68.8 | 0.3 | 6570 | 200 |
| 2019 | forecast | 177 | 245 | 465.5 | 384586 | 346 | 2.7 | 71.1 | 0.5 | 6426 | 202 |
| 2020 | | 185 | 247 | 501.9 | 333932 | 356 | 3.0 | 73.4 | 0.7 | 6286 | 204 |
| 2021 | | 193 | 249 | 541.2 | 289949 | 366 | 3.2 | 75.8 | 1.0 | 6148 | 206 |
| 2022 | | 201 | 251 | 583.4 | 251759 | 376 | 3.5 | 78.4 | 1.5 | 6013 | 208 |
| 2023 | | 210 | 253 | 629.0 | 218600 | 386 | 3.8 | 80.9 | 2.3 | 5882 | 210 |
| 2024 | | 219 | 255 | 678.2 | 189807 | 396 | 4.1 | 83.6 | 3.4 | 5753 | 212 |

*Author's estimates are presented due to the lack of statistical data.
Source: compiled by the author based on information from Rosstat (2020)

According to Table 2, the vegetable yield in 2018 was 243 hundred kilograms per hectare of harvested acreage and, according to the forecasts, it will increase to 255 by 2024. The potato yield is lower – in 2018, it was 170 hundred kilograms per hectare of harvested acreage and, according to the forecasts, it will increase to 219 by 2024. The estimatedvolume of fixed investment as an indicator of modernization of equipment and technologies in 2018 was 431.8 billion rubles, and it will increase to 678.2 billion rubles by 2024.

The volume of simultaneous storage of potato, fruits and vegetables as an indicator of adequate supply of logistics services in 2018 was 442925 tons, and it will decrease to 189807 tons by 2024. Tractor workload as an indicator of adequate supply of equipment in 2018 was 337 hectares, and it will increase to 396 hectares by 2024. The volume of application of chemical fertilizers to crops in 2018 was 2.5 million tons, and it will increase to 4.1 million tons by 2024.

The volume of application of organic fertilizers to crops in 2018 was 68.8 million tons, and it will increase to 83.6 million tons by 2024. The volume of chemical reclamation activities (liming of acid soils) in 2018 was 0.3 million hectares, and it will increase to 3.4 million hectares by 2024. The irrigation water use in 2018 was 6570 million m3, and it will increase to 5,753 million m3 by 2024. The generating capacities per 100 hectares of crop area in 2018 were 200 h.p. (horse powers), and they will increase to 212 h.p. by 2024.

The results of regression analysis are presented in Table 3, 4.

**Table 3.** Regression analysis of the impact of potential factors x1-x8 on the response variables $y_1$-$y_4$

| - | $y_1$ | | $y_2$ | | $y_3$ | | $y_4$ | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient b | P-value | Coefficient b | P-value | Coefficient b | P-value | Coefficient b | P-value |
| Constant a | -55.78364 | 0.006167 | -7.384672 | 3.25872E-06 | 979.2682 | 4.20251E-05 | 979.268 | 4.20251E-05 |
| x1 | 0.085619 | 0.000225 | -0.000203 | 0.000367653 | 0.487169 | 1.44903E-05 | 0.48717 | 1.44903E-05 |
| x2 | 9.67E-06 | 0.000273 | -3.12E-08 | 0.000240528 | -1.71E-06 | 0.017642486 | -1.7E-06 | 0.017642486 |
| x3 | 0.910812 | 0.0001 | 0.025914 | 1.13689E-06 | -3.695424 | 1.26788E-05 | -3.69542 | 1.26788E-05 |
| x4 | -0.012364 | 0.077865 | 3.78E-05 | 0.076769205 | 0.015835 | 0.095850424 | 0.01584 | 0.095850424 |
| x5 | -6.207606 | 4.02E-06 | -0.031105 | 1.47045E-06 | 11.24125 | 2.55341E-06 | 11.2413 | 2.55341E-06 |
| x6 | -0.072307 | 0.00566 | 0.000211 | 0.006096385 | 0.171503 | 0.002104548 | 0.1715 | 0.002104548 |
| x7 | 0.004904 | 0.000884 | 0.000162 | 7.42712E-06 | -0.037793 | 3.09987E-05 | -0.03779 | 3.09987E-05 |
| x8 | 0.828526 | 0.000107 | 0.081639 | 1.01333E-07 | -1.90401 | 4.22485E-05 | -1.90401 | 4.22485E-05 |

Source: calculated and compiled by the author.

**Table 4**. Regression analysis of the impact of potential factors x1-x8 on the response variables$y_5$-$y_8$

| - | $y_5$ | | $y_6$ | | $y_7$ | | $y_8$ | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient b | P-value | Coefficient b | P-value | Coefficient b | P-value | Coefficient b | P-value |
| Constant a | 22.6194 | 4.46468E-05 | -300.37 | 3.30023E-05 | 333.552 | 1.24181E-05 | -571.04 | 0.00032 |
| $x_1$ | 0.00262 | 0.00028452 | -0.1542 | 1.06909E-05 | 0.02435 | 0.000198823 | -0.1668 | 0.00032 |
| $x_2$ | 3.1E-07 | 0.000313198 | -5E-06 | 0.000186898 | 2.8E-06 | 0.000230553 | -2E-05 | 0.0003 |
| $x_3$ | 0.01483 | 0.000446144 | -0.0112 | 0.088930419 | -1.0024 | 5.90701E-06 | 1.5121 | 0.0002 |
| $x_4$ | -0.0004 | 0.078047462 | 16.005 | 8.07364E-09 | -0.0033 | 0.076476907 | 0.02887 | 0.07783 |
| $x_5$ | -0.1177 | 1.31997E-05 | 2.74821 | 3.15644E-06 | 7.33134 | 2.05795E-07 | 0.56911 | 0.0026 |
| $x_6$ | -0.0025 | 0.005675935 | 0.02347 | 0.008229156 | -0.0185 | 0.006184631 | 0.16738 | 0.00575 |
| $x_7$ | 0.00086 | 3.40902E-05 | 0.01764 | 1.05104E-05 | -0.0129 | 9.14664E-06 | 0.0591 | 3.3E-05 |
| $x_8$ | -0.0546 | 2.91212E-05 | 0.53165 | 4.00352E-05 | -1,2862 | 3.1739E-06 | -0.2077 | 0.00917 |

Source: calculated and compiled by the author.

According to Table 3, the most significant (statistically significant, that is, p-value did not exceed 0.05) positive factors of the marketability of potatoes in agricultural organizations (y1) turned out to be as follows: tractor workload as an indicator of adequate supply of equipment (x3) (coefficient b was 0.91) and the generating capacities per 100 hectares of crop area (x8) (coefficient b was 0.83). The most significant (statistically significant) positive factor of the marketability of potatoes in private households (y2) turned out to be the generating capacities per 100 hectares of crop area (x8) (coefficient b was 0.08).

The most significant (statistically significant) positive factors of the marketability of potatoes in peasant (private) farms (y3) and factors of the marketability of vegetables in agricultural organizations (y4) turned out to be as follows: fixed investment as an indicator of modernization of equipment and technologies (x1) (coefficient b was 0.48) and the volume of application of organic fertilizers to crops (x5) (coefficient b was 11.24).

According to Table 3, the most significant (statistically significant) positive factors of the marketability of vegetables in private households (y5) turned out to be as follows: fixed investment as an indicator of modernization of equipment and technologies (x1) (coefficient b was 0.002) and tractor workload as an indicator of adequate supply of equipment (x3) (coefficient b was 0.01). The most significant (statistically significant) positive factors of the marketability of vegetables in peasant (private) farms (y6) turned out to be as follows: the volume of application of chemical fertilizers to crops (x4) (coefficient b was 16.00), the volume of application of organic fertilizers to crops (x5) (coefficient b was 2.45) and the generating capacities per 100 hectares of crop area (x8) (coefficient b was 0.53).

The volume of application of organic fertilizers to crops (x5) turned out to be the most significant (statistically significant) positive factor of potato yield (y7) (coefficient b was 7.33). The most significant (statistically significant) positive factors of the vegetable yield (y8) turned out to be as follows: the volume of application of organic fertilizers to crops (x5) (coefficient b was 0.57) and chemical reclamation activities (x6) (coefficient b was 0.17).

The quality of agricultural products in Russia has been optimized on the basis of identified regressional relationships using the simplex method; the results of this optimization are presented in Table 5.

**Table 5.** Results of optimization of quality of agricultural products in Russia using the simplex method

| - | Optimization condition (target value y) and the values of the factor variables (x1-x8) for observing it | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $y_1$=100 | $y_2$=100 | $y_3$=100 | $y_4$=100 | $y_5$=100 | $y_6$=100 | $y_7$=219 | $y_8$=255 |
| $x_1$ | 433.72 | 433.64 | 424.97 | 425.14 | 446.24 | 446.24 | 454.30 | 454.35 |
| $x_2$ | 443152.66 | 344069.07 | 343231.12 | 414040.72 | 413970.42 | 5639.63 | 5639.62 | 14425,56 |
| $x_3$ | 349.42 | 349.40 | 1067.55 | 1067.55 | 58.23 | 58.23 | 57.19 | 57.19 |
| $x_4$ | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.51 |
| $x_5$ | 65.27 | 65.27 | 35.19 | 35.19 | 38.52 | 38.52 | 39.91 | 39.91 |
| $x_6$ | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| $x_7$ | 6595.42 | 6524.33 | 8091.02 | 8092.24 | 7499.13 | 7498.89 | 7322.28 | 7348.30 |
| $x_8$ | 203.98 | 203.97 | 975.02 | 975.02 | 541.23 | 541.22 | 494.88 | 495.04 |

Source: calculated and compiled by the author

Based on data from Table 5, the arithmetic means of the factor variables were determined, that are expected to be taken by them for achieving target values of response variables. They turned out to be as follows: $x_1$=439,8, $x_2$=248021,1, $x_3$=383,1, $x_4$=2,5, $x_5$=44,7, $x_6$=0,3, $x_7$=7371,5, $x_8$=553,8. Given the obtained optimization values of the factor variables, the response variables will take the following values: $y_1$=63,2, $y_2$=16,5, $y_3$=52,7, $y_4$=87,9, $y_5$=15,5, $y_6$=78,6, $y_7$=170, $y_8$=243. The increment in the independent (factor) and dependent (response) variables in accordance with the optimization results is shown in Figure 1.

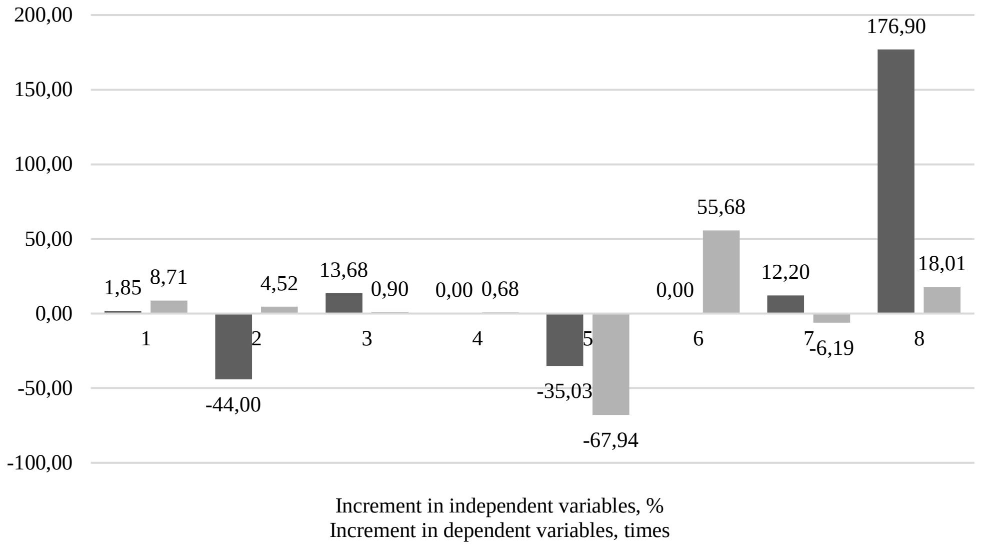


**Figure 1**. The increment in the independent (factor) and dependent (response) variables in accordance with the optimization results
Source: calculated and compiled by the author

As can be seen from Figure 1, the volume of fixed investment is expected to increase by 1.85%, the volume of simultaneous storage of potato, fruits and vegetables is expected to decrease by 44%, tractor workload is expected to increase by 13.68%, the application of chemical fertilizers to crops and chemical reclamation activities should not be changed. It is expected that the volume of application of organic fertilizers to crops will decrease by 35.03%, the irrigation water use will increase by 12.20%, and the generating capacities will increase by 176.90%.

As a result, the marketability of potatoes in agricultural organizations will increase by a factor of 8.71, the marketability of potatoes in private households will increase by a factor of 4.52, the marketability of potatoes in peasant (private) farms will increase by a factor of 0.90, the marketability of vegetables in agricultural organizations will increase by a factor of 0.68, the marketability of vegetables in peasant (private) farms will increase by a factor of 55.68, the vegetable yield will increase by a factor of 18.01. Nevertheless, the marketability of vegetables in private households will decrease by a factor of 67.94, and the potato yield will decrease by a factor of 6.19.

### 4.2. The qualitative analysis of processes in regional land tenure through the example of the Kirov Region

In the Kirov region there are 330 agricultural organizations, 131 consumer cooperatives, nearly 400 peasant (farm) enterprises, 168 thousand of private subsidiary farms of the population. Agricultural production is developed on an area of almost 1 million hectares in 40 administrative districts. A significant part of regional municipal entities is agriculturally specialized, the share of the rural population is 24 per cent. In 2015 the volume of production amounted to 37.1 billion rubles (0.7 per cent in the total volume of agricultural goods produced in Russia, 44th in the rating of Russian regions). Kirov region produced 3.2 per cent of all agricultural goods of the Volga Federal District (Polunin and Petrov, 2012).

For the qualitative analysis of processes in regional land tenure associated with the establishment of their signs and properties through the methods of economic theory, we used the accounting and statistical reporting of agricultural organizations of the Kirov region. Below we given the data on presence and dynamic pattern of agriculturally unused lands in the Kirov region (Table 6).

**Table 6.** Dynamic pattern and presence of agriculturally unused lands and shortfall in gross output for the term of 2011-2016 in the Kirov region

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Absolute deviation of 2016 to 2011 |
|---|---|---|---|---|---|---|---|
| Unused lands:<br>- idle lands (other lands) (th.ha)<br>- undistributed lands (th.ha))<br>- disturbed lands (th.ha) | 156.0<br>381.1<br>12.9 | 156.0<br>377.9<br>12.9 | 156.0<br>376.4<br>12.9 | 155.5<br>375.1<br>13.0 | 155.9<br>374.5<br>12.9 | 156<br>373.7<br>12.9 | 0<br>-7.4<br>0 |
| A total area of unused land, th.ha | 550.0 | 546.8 | 545.3 | 543.6 | 543.3 | 542.6 | -7.4 |
| Agricultural lands, th.ha | 4313.7 | 4180.6 | 4102.8 | 4044.9 | 4030.8 | 3935.3 | -378.4 |
| Crop industry gross output, th.rub. | 3592.9 | 2644.7 | 3 842. 0 | 6 295. 2 | 5 473.1 | 4 887. 7 | 1294.8 |
| For reference:<br>Land redistribution fund, th.ha | 446.8 | 466.4 | 455.2 | 717.9 | 717.2 | 694.4 | 247.6 |
| The volume of crop industry gross output lost on unused area, th.rub. | 458.1 | 345.9 | 510.6 | 846.0 | 737.7 | 673.9 | 215.8 |

Source: plotted by the author.

An important task of studying the processes in agricultural land tenure is to determine the dynamic pattern of its development, which is influenced in time by various forces. The main one in the development is the dynamic pattern of used and unused agricultural lands. Temporal variation of the process should be free from the impact of various random forces (achieved by extending time frames) in a longer period, namely in the annual one. Revealing the main trends of the process in land tenure is carried out by the sliding values method of used and unused lands, as well as performances of types of crop industry gross output (Figures 2, 3, 4).

A quantitative model that graphically demonstrates the main trend of time series variation for used and unused lands is presented in Figure 4.

The main contents of the dynamic pattern of types of crop industry gross output (Figure 4) is a negative general development trend. The absolute deviation of the volume of crop industry gross output lost on unused area over a term of 2016 to 2011 is 215.8 thousand rubles (Table 2). For these terms the area of agriculturally designated lands in the Kirov region decreased by 8.8 per cent

(Figure 1). The volume of crop industry gross output lost on unused area increased by 47 per cent in 2016 in contrast to 2011 (Figure 3). As a whole, the area of unused lands decreased by just 7.4 th. ha over a studied lapse of years, but the area of idle lands (other lands) and disturbed ones stayed the same (Fig. 3).

When considering the values of used and unused lands, as well as performances of types of crop industry gross output by categories of economic entities of regional land users, the development trend turns out to be different (Table 7).

A quantitative model that graphically demonstrates the development trend by categories of land users with regard to used land time series is presented in Figure 5.

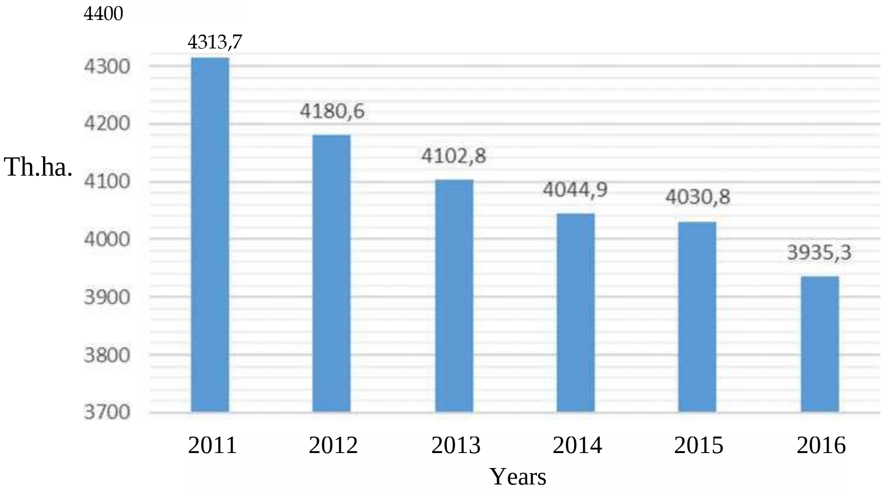


**Figure 2.** The dynamic pattern of use of agriculturally designated lands in the Kirov region from 2011 till 2016, th.ha.
Source: plotted by the author

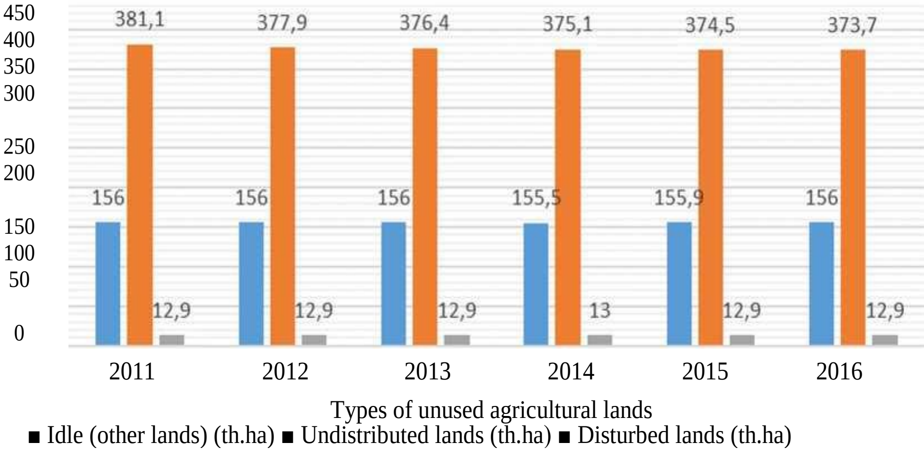


**Figure 3.** Dynamic pattern of unused lands in the Kirov region from 2011 till 2016, th. ha.
Source: plotted by the author

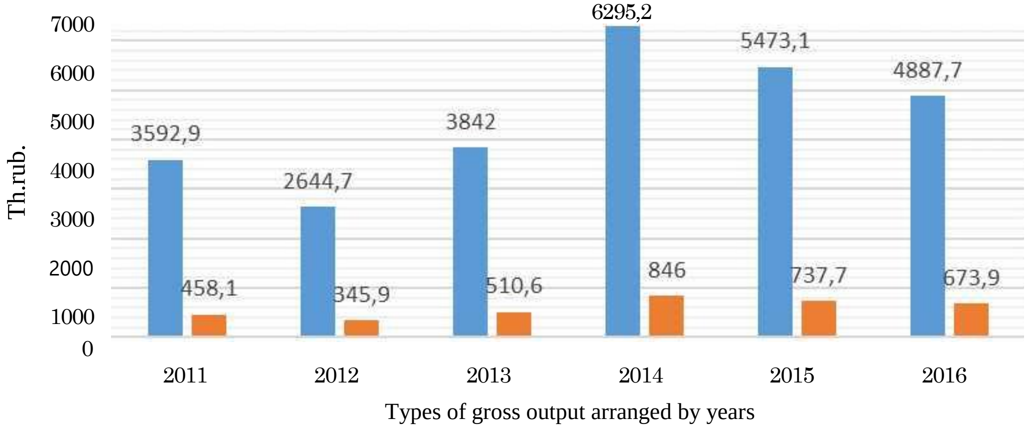


**Figure 4.** Dynamic pattern of types of crop industry gross output in the Kirov region from 2011 till 2016, th. rub.
Source: plotted by the author

**Table 7.** The use of agricultural lands by citizens and their collectives in the Kirov region over a term of 2011-2016 (th. ha)

| Ser.No. | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Absolute deviation of 2016 to 2011 |
|---|---|---|---|---|---|---|---|---|
| 1 | Peasant (farm) household | 58.6 | 59.3 | 62.1 | 62.1 | 58.6 | 59.8 | 1.2 |
| 2 | Individual entrepreneurs who didn't establish peasant (farm) household | 0.8 | 1.6 | 1.7 | 2.7 | 13.1 | 16.8 | 16.0 |
| 3 | Private subsidiary farms | 79.7 | 79.7 | 79.7 | 79.9 | 80.1 | 81.1 | 1.4 |
| 4 | Service allotment citizens | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | -0.1 |
| 5 | Horticulturists and horticultural associations | 12.6 | 12.6 | 12.6 | 12.6 | 12.6 | 12.6 | 0 |
| 6 | Market-gardeners and market-gardening associations | 2.3 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | -0.1 |
| 7 | Allotment gardeners and dacha associations | 0.4 | 0.5 | 0.5 | 0.9 | 0.9 | 1.0 | 0.6 |
| 8 | Citizens having land plots provided for private housing construction | 5.2 | 5.4 | 6.2 | 6.6 | 7.1 | 7.5 | 2.3 |
| 9 | Livestock farmers and livestock associations | 8.1 | 8.1 | 8.0 | 7.7 | 7.6 | 7.7 | -0.4 |

**Table 7.** The use of agricultural lands by citizens and their collectives in the Kirov region over a term of 2011-2016 (th. ha) (continued)

| Ser.No. | | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Absolute deviation of 2016 to 2011 |
|---|---|---|---|---|---|---|---|---|
| 10 | Citizens mowing and livestock grazing | 27.2 | 27.2 | 27.1 | 27.1 | 26.9 | 26.8 | -0.4 |
| 11 | Citizens-owners of land plots | 101.5 | 149.4 | 159.9 | 144.5 | 150.4 | 154.9 | 53.4 |
| 12 | Citizens-owners of farmland entitlement | 133.1 | 107.6 | 106.8 | 135.6 | 140.0 | 138.7 | 5.6 |
| 13 | Total lands | 429.7 | 453.7 | 466.9 | 482.0 | 499.6 | 509.2 | 79.5 |
| 14 | Including lands of closed down peasant (farm) households and individual entrepreneurs for whom the issue of land title termination is not resolved | 23 | 23.4 | 25.6 | 29.0 | 28.2 | 28.7 | 5.7 |

Source: compiled by the author.

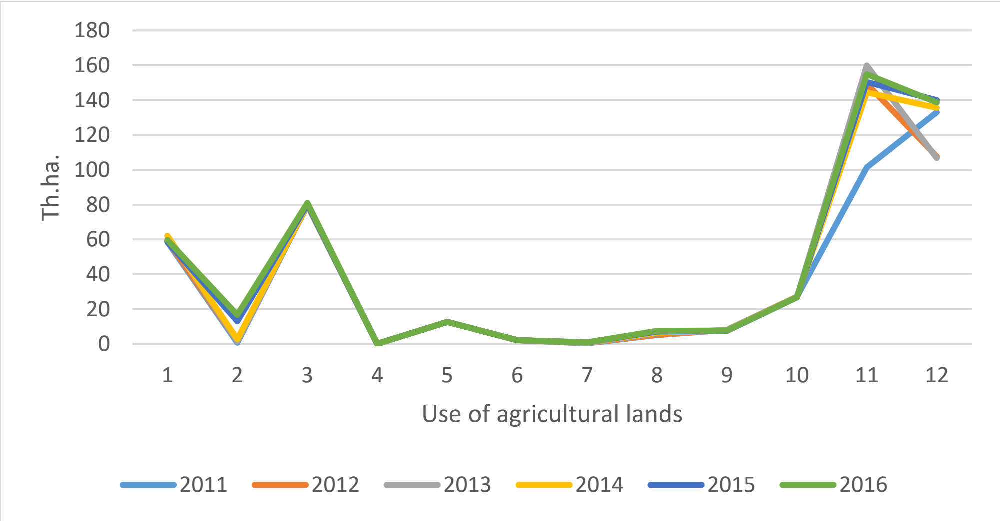


**Figure 5.** Dynamic pattern of use of agriculturally designated lands by citizens and their collectives in the Kirov region over a term of 2011-2016 (th.ha), where horizontally from 1 to 12 is a serial number of Table 2.
Source: plotted by the author

Agricultural land use is featured by the greatest absolute increase (see Table 2 and Figure 4):

- firstly, citizens-owners of land plots - 53.4 th. ha;
- secondly, individual entrepreneurs who didn't establish a peasant (farm) household – 16 th.ha;
- and thirdly, the citizens-owners of farmland entitlements and lands of closed down peasant (farm) households and individual entrepreneurs, for whom the issue of termination of land title is not resolved - 5.7 th. ha.

One of the key constraining forces for the development of the industry is:

- Insufficient investments. The business is aimed at an immediate result which is quite impossible in farming agriculture, therefore we should find out ways to interact with the business by constructing the dialogue;
- Current economic conditions for agricultural performance and its technical and technological level;
- Dependence of the domestic agro-industrial complex on foreign equipment and technologies.

Modern systemwide processes in agricultural land tenure are impossible without specific state regulation of rational use:

- lack of an ecologically balanced system of agricultural land tenure;
- stable trends in the deterioration of the qualitative state of fertility;
- reduction of productive agricultural lands;
- lack of restrictions on title to land reflecting the need for its rational use;
- lack of close interrelation from agricultural, economic, ecological and social points of view;
- lack of measures to save productive agricultural lands;
- lack of legal enactments in the land legislation to counter latifundium system and land speculation;
- lack of law enforcement to prohibit the withdrawal of specific agricultural lands located in designated zones.

## 5. Conclusion

In modern conditions it is necessary to carry out more wide and systematic application of economic methods to effect on economic entities - land users, namely: land tax, cadastral value of agriculturally designated land plots, acquisition of the right to develop productive agriculturally designated lands, administrative liability for land offenses (fines, indemnification as a result of the commission of land offenses, rendering the land plot into suitable state in the event of damage). An important measure to improve land relations is the economic coercion of land management with the development and implementation of anti-erosion and other environmental actions in accordance with the land management documentation developed. In the event of non-implementation of land management and non-compliance with regulations on non-exhaustive use of agricultural lands, the state should terminate public support of agricultural organizations (Government of the Kirov Region, 2020).

The main conclusion: on the basis of qualitative economic analysis and calculation of performances of the dynamic pattern of land tenure processes by means of statistical analysis of univariate time series, it is possible to obtain a forecast of the stability level of the process development in time, the value of an appropriate forecasting period. It will make possible to take prompt decisions on crop industry management.

Based on the results of the research, inference should be drawn that the key quality factors of agricultural products (horticulture) in Russia are tractor workload as an indicator of adequate supply of equipment, application of organic fertilizers to crops, and the generating capacities per 100 hectares of crop area, since they have the most consistent and strong influence on the marketability and the yield of crop products (potatoes and vegetables).

In order to maximize the marketability and the yield, tractor workload as an indicator of adequate supply of equipment should be increased by 13.68%, the generating capacities per 100 hectares of crop area should be increased by 176,90%, and it is expected that the volume of application of organic fertilizers to crops will decrease by 35.03%. Despite the high accuracy of recommendations made for quality control of agricultural products in horticulture, optimization capabilities are limited, and it prevents from increasing the marketability of vegetables in private households and the potato yield.

Nevertheless, prominent positive results will be reached: the marketability of potatoes in agricultural organizations will increase by a factor of 8.71, the marketability of potatoes in private households will increase by a factor of 4.52, the marketability of potatoes in peasant (private) farms will increase by a factor of 0.90, the marketability of vegetables in agricultural organizations will increase by a factor of 0.68, the marketability of vegetables in peasant (private) farms will increase by a factor of 55.68, and the vegetable yield will increase by a factor of 18.01.

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**Elena V. Sofiina**
Federal Research Center of Agricultural Economics and Social Development of Rural Territories – Russian Research Institute of Agricultural Economics, Moscow, Russian Federation;
Vyatka State Agricultural Academy;
Vyatka State University;
Kirov, Russian Federation
evsofina@mail.ru