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STRATEGIC MANAGEMENT OF AGRICULTURAL PRODUCTIVITY TO INCREASE FOOD SELF-SUFFICIENCY IN NORTHERN TERRITORIES

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Abstract

At present, the issues of food security and self-sufficiency are raised globally. The Russian Federation is developing strategic planning documents at different administrative levels to ensure the country's food security. A special priority is given to the self-sufficiency of regions in domestic agricultural products. This goal is harder to achieve in the northern and Arctic regions due to their harsh climate, low soil fertility, and poor transport and economic development of these vast territories. There is now an urgent need for new approaches to the development of agriculture in the North. The article is devoted to assessing the food self-sufficiency of Russia's northern constituent entities in a 12-year period with crop yield as the leading factor. The primary research methods include content analysis, statistical and comparative analysis, and graphic modeling. The findings suggest that the northern regions have low self-sufficiency in potatoes and vegetables, which is associated with the insufficient area of cultivated land and harsh climate. The authors conclude that each northern constituent entity of Russia, depending on its cultivation conditions, requires high-yielding varieties of certain crops adapted to local conditions. In particular, the regions need early maturing crop varieties resistant to low spring and early fall temperatures.

Keywords: food self-sufficiency, crop yields, agriculture, northern regions, the Arctic.

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GESTÃO ESTRATÉGICA DA PRODUTIVIDADE AGRÍCOLA PARA AUMENTAR A AUTOSUFICIÊNCIA ALIMENTAR NOS TERRITÓRIOS DO NORTE

Resumo

Actualmente, as questões da segurança alimentar e da auto-suficiência são levantadas a nível mundial. A Federação Russa está a desenvolver documentos de planeamento estratégico a diferentes níveis administrativos para garantir a segurança alimentar do país. É dada especial prioridade à auto-suficiência das regiões em produtos agrícolas nacionais. Este objectivo é mais difícil de alcançar nas regiões do Norte e do Árctico devido ao seu clima rigoroso, à baixa fertilidade do solo e aos fracos transportes e desenvolvimento económico destes vastos territórios. Existe agora uma necessidade urgente de novas abordagens para o desenvolvimento da agricultura no Norte. O artigo dedica-se a avaliar a auto-suficiência alimentar das entidades constituintes do norte da Rússia num período de 12 anos, tendo o rendimento das colheitas como factor principal. Os principais métodos de pesquisa incluem análise de conteúdo, análise estatística e comparativa e modelagem gráfica. As conclusões sugerem que as regiões do norte têm baixa auto-suficiência em batatas e vegetais, o que está associado à área insuficiente de terra cultivada e ao clima rigoroso. Os autores concluem que cada entidade constituinte do norte da Rússia, dependendo de suas condições de cultivo, requer variedades de alto rendimento de certas culturas adaptadas às condições locais. Em particular, as regiões necessitam de variedades de culturas de maturação precoce resistentes às baixas temperaturas da Primavera e do início do Outono.

Palavras-chave: autossuficiência alimentar, rendimento agrícola, agricultura, regiões setentrionais, Ártico.

GESTIÓN ESTRATÉGICA DE LA PRODUCTIVIDAD AGRÍCOLA PARA AUMENTAR LA AUTOSUFICIENCIA ALIMENTARIA EN LOS TERRITORIOS DEL NORTE

Resumen

En la actualidad, las cuestiones de la seguridad alimentaria y la autosuficiencia se plantean a nivel mundial. La Federación de Rusia está elaborando documentos de planificación estratégica en diferentes niveles administrativos para garantizar la seguridad alimentaria del país. Se da especial prioridad a la autosuficiencia de las regiones en productos agrícolas nacionales. Este objetivo es más difícil de lograr en las regiones del norte y del Ártico debido al duro clima, la baja fertilidad del suelo y el deficiente transporte y desarrollo económico de estos vastos territorios. Ahora existe una necesidad urgente de nuevos enfoques para el desarrollo de la agricultura en el Norte. El artículo está dedicado a evaluar la autosuficiencia alimentaria de las entidades constituyentes del norte de Rusia en un período de 12 años, teniendo el rendimiento de los cultivos como factor principal. Los principales métodos de investigación incluyen análisis de contenido, análisis estadístico y comparativo y modelado gráfico. Los resultados sugieren que las regiones del norte tienen una baja autosuficiencia en patatas y hortalizas, lo que se debe a la insuficiente superficie de tierra cultivada y al duro clima. Los autores concluyen que cada entidad del norte de Rusia, dependiendo de sus condiciones de cultivo, necesita variedades de alto rendimiento de determinados cultivos adaptadas a las condiciones locales. En particular, las regiones necesitan variedades de cultivos de maduración temprana y resistentes a las bajas temperaturas de primavera y principios de otoño.

Palabras clave: autosuficiencia alimentaria, rendimiento de los cultivos, agricultura, regiones del norte, Ártico.

INTRODUCTION

The United Nations (UN) predicts that by 2050, the world population will increase by another two billion and reach 9.7 billion, and by 2100, it will hit the 11 billion mark. The lack of due attention to food self-sufficiency on the part of each particular state will increase the risk of global famine and malnutrition among the population. The UN has proclaimed the liquidation of hunger, improvement of nutrition, and support for the development of agriculture as one of its chief goals in sustainable development, given that currently, 8.9% of the world's population is starving. The constant rise in global population demands not only the political will to solve the issues of hunger and malnutrition and the redistribution of food but also the use of new approaches to raise the productivity of agriculture. To combat hunger, the UN has established a separate global political institution – the Food and Agriculture Organization, which, among other functions, assists countries in improving agricultural practices [1].

Each modern state faces the task of ensuring its people's food security both through domestic production and through exchange via global trade. However, the current geopolitical situation, climate change, environmental, technogenic, and natural disasters, and the protectionist policy of individual countries call for ensuring the food security of spatial-territorial units of a lower taxonomic level – macro-regions and regions within individual states.

Northern and Arctic regions are particularly vulnerable in terms of food self-sufficiency, which negatively affects their security. This is primarily due to the harsh climate, low soil fertility, and poor transportation and economic development of these vast territories. One of the strategic tasks of Russia in the Arctic is ensuring food security, i.e., providing the population with quality produce, raw materials, and agricultural products. This task can be accomplished by developing stable domestic production of crops resistant to unfavorable conditions in the North and increasing their yields by soil enrichment.

However, the development of crop production, and agriculture in general, in the North is constrained by several factors that have been identified by researchers in different disciplines. For instance, V.A. Ivanov identifies the following key factors: harsh climate, low soil quality, and a short vegetation period [2]. The influence of climate change on crop yield and, as a consequence, the development of regional economies, has been investigated by both Russian (S.O. Siptits, V.M. Kostusiak, I.A. Romanenko [6], V. Romanenkov, P. Krasilnikov [7, 8], A.S. Scherbakova [9], O.D. Sirotenko, V.N. Pavlova [10], and others) and foreign researchers (T. Kjellstrom, R.S. Kovats, S.J. Lloyd [3, 4], S.N. Gosling, D. Ibarreta [5], and others). Researchers argue that climate change has led to an increase in the vegetation period and the

expansion of farming areas, which creates conditions for the sustainable development of crop production in the North and ensures food self-sufficiency in the regions. Food self-sufficiency is a new economic category from the standpoint of the essence and research methodology. Food self-sufficiency is also closely intertwined with the concepts of food security and food provision.

Food security and self-sufficiency have been explored by R. Capone et al. [11] and O. Olaoye [12], N.N. Semenova [13], V.V. Smirnov [14], I.G. Ushachev [15], V.A. Ivanov [16], and E.N. Antamoshkina [17]. The level of food self-sufficiency is typically assessed using several coefficients. In her work on assessment methods, E.N. Antamoshkina clarifies that the self-sufficiency coefficient and other coefficients and indices need to be calculated for those types of agricultural products that can be widely cultivated in the region given its climate [17].

In addition, researchers place an emphasis on the quality characteristics of northern soils. V.A. Ivanov notes that northern territories are characterized by the weakest soil development processes, limited activity of soil microorganisms, and low content of humus and nutrients available to plants. Given this, several researchers recommend using forestry industry waste as organo-mineral fertilizers, which can considerably promote activities in the field of effective waste management [18].

At present, there is a need for new approaches to the development of agriculture in the North. The study of local agricultural crops' yield as a factor in food self-sufficiency with the use of a differential approach to northern regions considering the existing bioclimatic conditions and potential to increase cultivated area will contribute to the increase of agricultural development in the territories under study.

Thus, the goal of the study is to assess the yield of potatoes and vegetables and to determine the degree of self-sufficiency of Russia's northern constituent entities in these agricultural crops.

To achieve the purpose of the study, it is necessary to address a set of interconnected objectives. The first objective is to conduct a comparative analysis of the existing scientific literature to determine the features of Russia's northern regions in the development of crop production and the specifics of crop cultivation. The second objective is to characterize the northern constituent entities of Russia by their climate and the availability of cultivated areas and to analyze the productivity of agricultural lands. The third objective is to assess the self-sufficiency of northern regions in potatoes and vegetables and to develop recommendations for its improvement.

The subject of the study is the constituent entities of Russia whose entire territory is attributed to the Far North region at the legislative level.

METHODS

The leading information sources for the study were data from the Federal State Statistics Service (Rosstat). The research focused on the period from 2010 to 2022 and utilized the methods of content analysis, statistical and comparative analysis, and graphic modeling.

The first stage of the research included an analysis of scientific literature devoted to northern regions in the context of crop production development and the specifics of crop cultivation.

In the second stage, the studied northern regions were classified based on the indicator of the share of cultivated area in the total area of the region, since this factor characterizes the level of agricultural development of the region in terms of crop production.

Next, we compiled and analyzed a database with indicators describing the yields and self-sufficiency of the considered constituent entities. For the indicator of crop production development, we considered potatoes and vegetables as agricultural crops.

In the fourth stage, we assessed the self-sufficiency of northern regions in potatoes and vegetables by calculating the corresponding coefficient. The proposed method was based on the indicators of food production and consumption prescribed by the Doctrine of Food Security of the Russian Federation (self-sufficiency in potatoes – no less than 95%, in vegetables – no less than 90%) [19]. In its extended version, the method analyzes the region’s food self-sufficiency level, the degree of satisfaction of the population's physiological needs in food products, and the level of economic accessibility of food. In this study, we examined only one of these aspects – the region’s food self-sufficiency.

The self-sufficiency coefficient describes the level of provision for the regional population's needs in various types of agricultural crops. In this study, we calculated the self-sufficiency index for potatoes and vegetables, since regardless of climate and other factors, all regions have the conditions and potential to grow them. Furthermore, potatoes and vegetables are socially important food crops. In the diet of residents of the northern regions, potatoes and vegetables serve as sources of various vitamins and mineral salts. The choice of crops will allow for fulfilling one of the objectives – comparative analysis based on several crops and assessment of the state of crop production as a factor of food security, which is most relevant in the North.

$$Cs=A/(n*A\_r) \quad (1)$$

The coefficient was calculated using the following statistical data:

A – gross crop yield;

n – population of the region;

Ar – rational norms of food consumption (rational norms of potato consumption – 90 kg/person, rational norms of vegetable consumption – 140 kg/person).

The concluding stage consisted of the comparative analysis and interpretation of the results, which allowed us to draw conclusions on the need for artificial soil improvement, including through the use of industrial wastes, to ensure sustainable food security.

RESULTS AND DISCUSSION

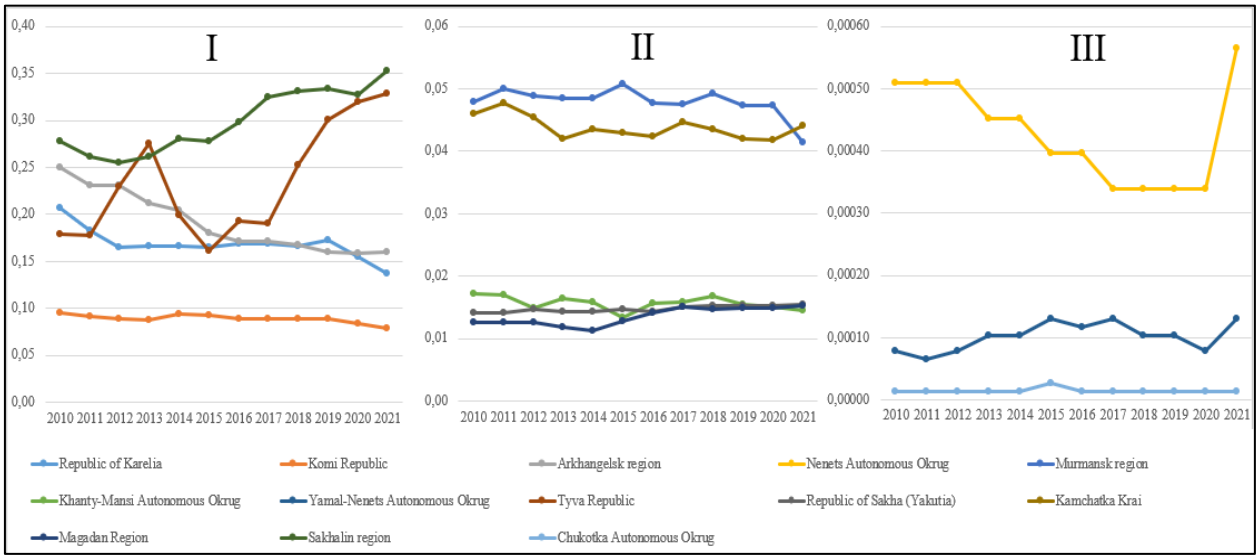
Based on statistical data as of the beginning of 2022, all northern constituent entities of Russia were divided into three groups by the area of sown land. The first group includes the Republic of Karelia, the Komi Republic, the Tyva Republic, the Arkhangelsk Oblast, and the Sakhalin Oblast. The second group consists of the Murmansk Oblast, the Magadan Oblast, the Khanty-Mansi Autonomous Okrug, the Kamchatka Krai, and the Republic of Sakha (Yakutia). The third group is made up of the Yamal-Nenets, Nenets, and Chukotka Autonomous Okrugs.

Based on Table 1, we can conclude that the share of the cultivated area is influenced by the severity of climate, as evidenced by the Bioclimatic Index of Severity of Climatic Regime (BISC).

Table 1. Characteristic of the northern regions of Russia based on climate and the availability of cultivated area

Group of regions	Constituent entity	Climate zone	BISC, points	Share of cultivated area as of 2021, %
First group (I)	Republic of Karelia	II, III	6	0.1368
	Komi Republic	I, II, III	5.2	0.0782
	Arkhangelsk Oblast	II, III	6	0.1600
	Sakhalin Oblast	II, III	6	0.3525
	Tyva Republic	III	6.5	0.3286
Second group (II)	Murmansk Oblast	I, II	4.5	0.0414
	Magadan Oblast	I	3.5	0.0154
	Republic of Sakha (Yakutia)	I, II	4.5	0.0154
	Khanty-Mansi Autonomous Okrug	II, III	6	0.0146
	Kamchatka Krai	I, II	4	0.0442
Third group (III)	Yamal-Nenets Autonomous Okrug	I, II	4.5	0.0001
	Nenets Autonomous Okrug	I	3.5	0.0006
	Chukotka Autonomous Okrug	I	3.5	0.00001

In general, the area of cultivated land in Russia is increasing. Specifically, from 2010 to 2021, the cultivated area of all crops grew from 74.8 to 80.4 million ha. This increase is provided by the constituent entities of the Volga, Central, Siberian, and Southern Federal Districts. Northern regions, however, show the opposite trend – in the same time period, their cultivated area reduced from 321.2 to 298.7 thousand ha. A negative trend in the cultivated area is observed in the Arkhangelsk Oblast (from 103.03 to 66.1 thousand ha), the Republic of Karelia (from 37.2 to 24.7 thousand ha), and the Komi Republic (from 39.49 to 32.6 thousand ha). Nevertheless, a major expansion of cultivated area has been achieved in the Tyva Republic (from 30.2 to 55.4 thousand ha) and the Sakhalin Oblast (from 24.25 to 30.7 thousand ha) [20].



Source: calculated by the authors

Figure 1. Share of cultivated area in the total area of the northern regions of the Russian Federation by groups, %

Figure 1 illustrates the dynamics in the share of cultivated area in the total area of Russia's northern regions in 2010-2021. The presented data suggest that these constituent entities have some reserves for efficient crop placement and the development of crop production and agricultural production. The best results are demonstrated by the Tyva Republic and the Sakhalin Oblast. The Tyva Republic is consistently expanding its cultivated areas, a major share of which is allocated for spring-sown wheat, barley, and oats. The Sakhalin Oblast, given its challenging weather conditions, is also actively increasing cultivated areas and grows potatoes, vegetables, and fodder crops [21]. The Nenets, Yamal-Nenets, and Chukotka Autonomous Okrugs have the lowest indicators in all of Russia, and the cultivated area in them is gradually decreasing. This can be attributed to low population, harsh climate, and high costs of crop production development compared to other northern regions. A sharp decrease in the share of

cultivated area is noted in the Arkhangelsk Oblast and the Republic of Karelia. On average across Russia, this indicator was around 4-5 %. We can thus conclude that Russia's northern regions, with the exception of the Tyva Republic and the Sakhalin Oblast, have a rather low level of agricultural development in their territories.

Further analysis of crop production development in the Russian North requires us to consider the productivity of agricultural land because the efficiency of agricultural work is affected not only by climate but also by the physicochemical properties and mineral content of soils. Russia's northern regions have unique natural characteristics of the soil formation process conditioned by temperature regimes, precipitation in the vegetation period, etc. In particular, low soil temperature hinders plants' ability to absorb the nutrients necessary to support vital processes.

To provide nutrients to plants, agricultural enterprises actively utilize both organic and inorganic fertilizers. In the soils of the North, the combined use of organic and mineral fertilizers is of great importance. The mixed application of fertilizers increases the level of nutrient absorption. In this study, we considered only the use of organic fertilizers, since they contribute to a better structure and temperature regime of the soil and create conditions for the efficient application of mineral fertilizer. Furthermore, the supply of organic fertilizers is provided by the peat reserves available in the northern regions and the development of livestock farming, which creates the potential for the territories' self-sufficiency in improving soil characteristics using their own resources [22].

To give an example, we shall consider the dynamics in the use of organic fertilizers by agricultural enterprises in the Federal Districts. Table 2 indicates that the leader in the use of organic fertilizers is the Northwestern Federal District. In 2021, the Murmansk Oblast applied 12.7 t of organic fertilizers per ha, the Arkhangelsk Oblast – 5.3 t/ha, the Komi Republic – 5.1 t/ha, and the Republic of Karelia – 4.5 t/ha. The average value in this Federal District is more than 3 times above the average across Russia. This extensive use of organic fertilizers owes to the need to increase the productivity of agricultural lands in the North to ensure food self-sufficiency.

Although the annual publication "Regions of Russia" by Rosstat does not report the annual data on this indicator in the past 5 years for many regions, we can provide some data for particular years. In 2005, the Nenets Autonomous Okrug used 20 t of organic fertilizers per ha of sown land, the Khanty-Mansi Autonomous Okrug – 5.2 t/ha, the Chukotka Autonomous Okrug – 6 t/ha, and Magadan Oblast – 5.5 t/ha. The least amount of organic fertilizers was used by the Republics of Sakha (Yakutia) and Tyva.

Table 2. Application of organic fertilizers per hectare of crops in agricultural organizations by federal districts, t [20]

	2010	2015	2019	2020	2021
Russian Federation	1.1	1.4	1.6	1.6	1.6
Central Federal District	1.5	2.2	2.6	2.6	2.6
Northwestern Federal District	2.9	4.6	4.8	5.1	5.3
Southern Federal District	0.8	0.8	0.8	0.8	0.7
North Caucasian Federal District	2.5	3	3.4	3.2	2.4
Volga Federal District	1	1	1.3	1.3	1.3
Ural Federal District	0.7	0.9	1.1	1.2	1.2
Siberian Federal District	0.5	0.6	0.7	0.7	0.8
Far Eastern Federal District	0.1	0.3	0.3	0.4	0.4

Fertilizer application is aimed at improving the soil parameters needed to increase crop yields.

Since 2010, particular attention has been paid to restoring and increasing the fertility of agricultural lands. On average across the country, potato yields increased by 60% in the studied 12 years. Among northern regions, only the Murmansk Oblast managed to surpass this level. Notably, in the Tyva Republic and Khanty-Mansi and Yamal-Nenets Autonomous Okrugs, potato yield as of the start of 2022 relative to 2010 decreased by 1.8, 14.9, and 34%, respectively (Figure 2). Northern regions of the Far Eastern Federal District are distinguished by an upward trend in this parameter. The remaining northern constituent entities of Russia display discontinuous changes, although in general, they show an increase in potato yield over the 12 years.

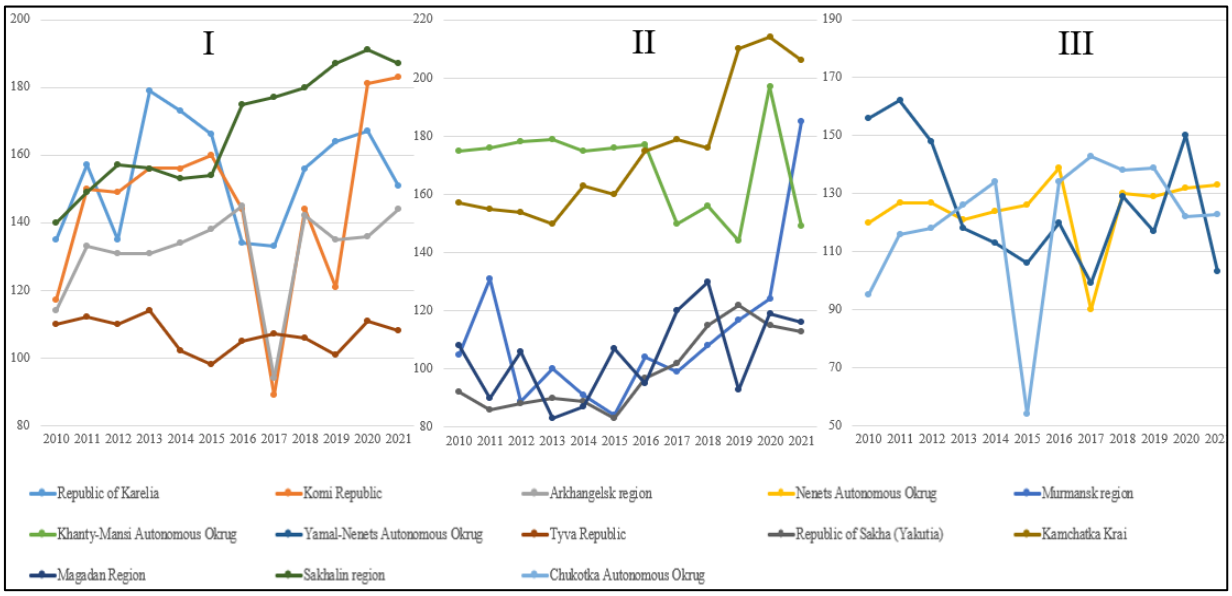


Figure 2. Yield of potatoes in the northern regions of the Russian Federation, c/ha of harvested area [20]

Figure 3 indicates that by vegetable yield, the northern regions have a less positive characterization. In the first group of regions, a positive trend is demonstrated only by the Sakhalin Oblast and the Tyva Republic. As of early 2022 compared to 2010, this indicator either shows a negative dynamic or is relatively stable in almost all constituent entities of the second group. A significant increase in potato yield is found in regions with the harshest natural conditions, which owes to the focused attention of the authorities to this issue.

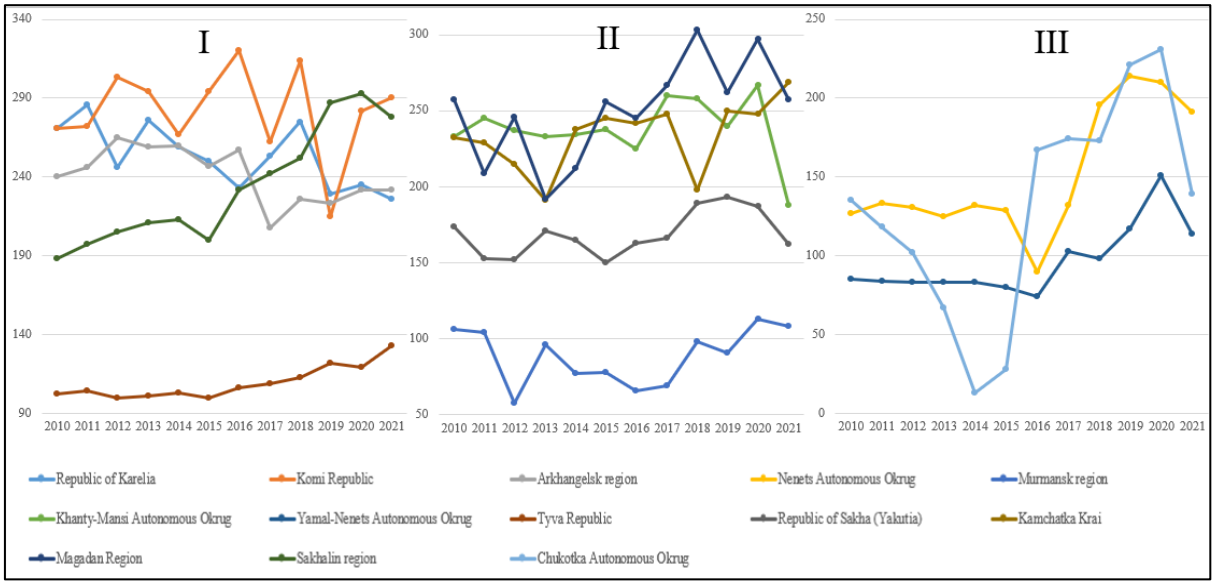
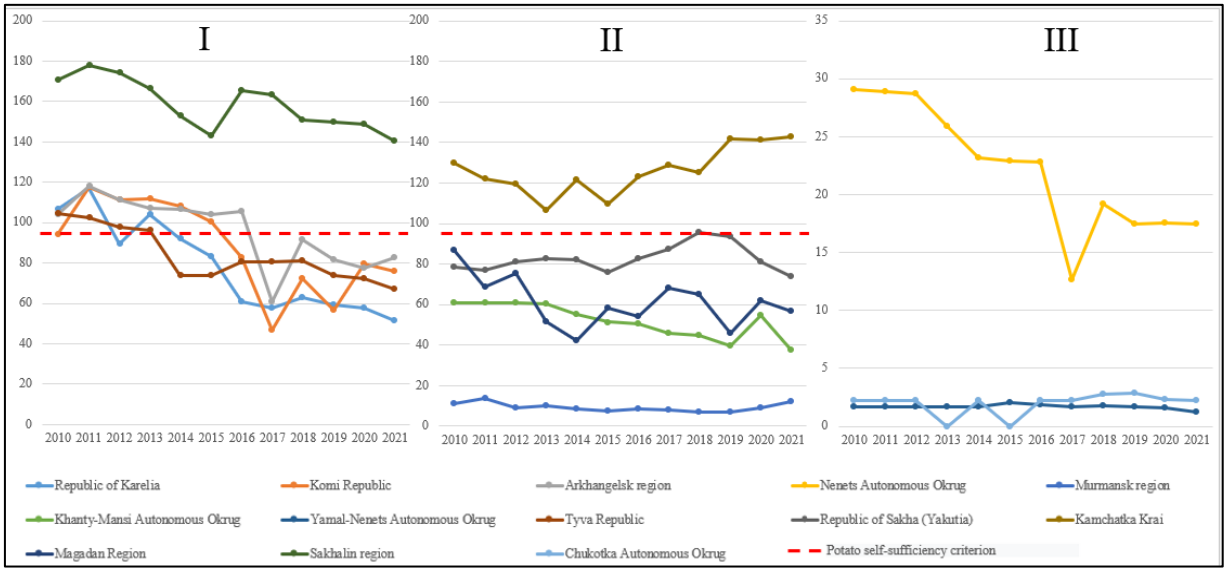


Figure 3. Yield of vegetables in the northern regions of the Russian Federation, c/ha of harvested area [20]

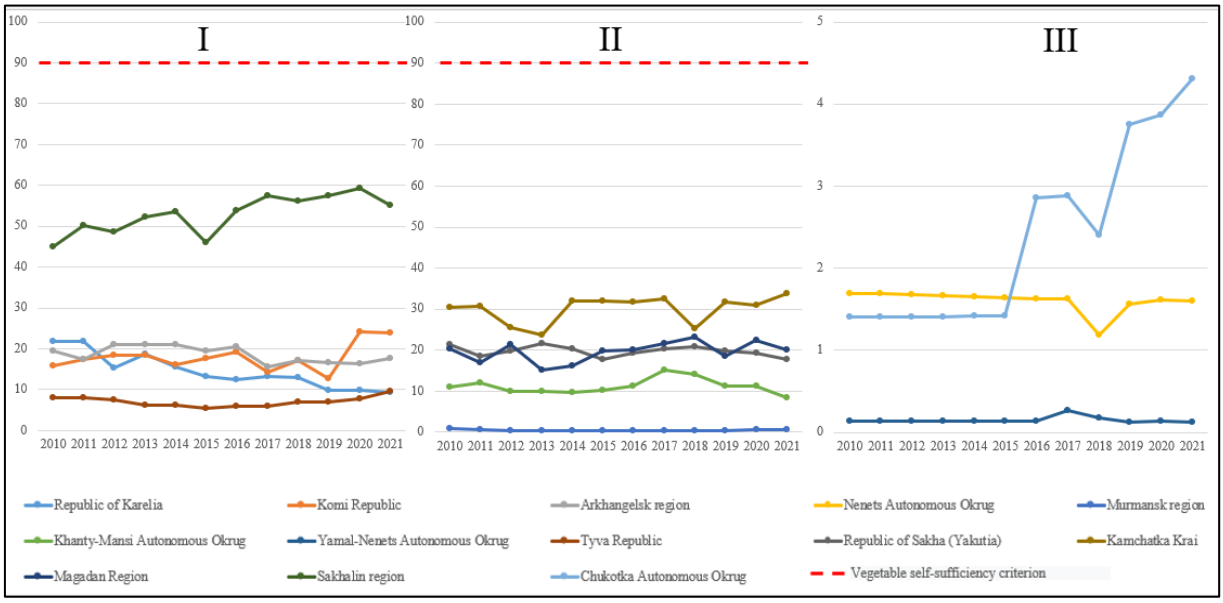
Figures 4 and 5 present the results on the provision of population with potatoes and vegetables in each northern constituent entity of the country, which is a critical factor in the socio-economic welfare and sustainability of any region.



Source: calculated by the authors

Figure 4. Potatoes self-sufficiency ratio in the northern regions of Russia, %

Figure 4 demonstrates the low potato self-sufficiency of the northern regions of Russia at the beginning of 2022, with the exception of the Sakhalin Oblast and the Kamchatka Krai. Furthermore, most northern constituent entities show a negative trend of further decrease in this indicator.



Source: calculated by the authors

Figure 5. Vegetables self-sufficiency ratio in the northern regions of Russia, %

As of early 2022, all northern regions are several times lower than the accepted normative value for vegetable security: the indices of groups I and II are over 3 times below the norm, except for the Sakhalin Oblast, and the security of group III is over 20 times lower than the threshold (Figure 5). Importantly, a positive dynamic of this indicator is observed in the constituent entities of the Far Eastern Federal District and the Komi Republic.

CONCLUSION

Our findings demonstrate the low level of potato and vegetable self-sufficiency in Russia's northern regions, which is attributed to the lack of agricultural land and the existing harsh climate. These factors directly affect yields and soil fertility.

Depending on growing conditions, each northern region needs high-yielding varieties of certain crops adapted to local conditions. Specifically, these regions require early maturing crop varieties resistant to low temperatures in spring and early fall.

To increase soil productivity in the northern regions, it is necessary to control the level of soil fertilization. For the purpose of preserving and restoring fragile ecosystems as part of

developing waste management and lean production policies in enterprises, some waste can be recycled to make new types of fertilizers (in particular, organo-mineral fertilizers in the forestry sector). This measure will be more efficient in improving both the environmental and agricultural components in the Russian North when actively supported by the state.

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