Ensuring food security through the development of acreage in the northern regions of the Russian Federation

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Abstract. Agricultural development is a determining factor in ensuring food security in the territories in the context of the global pandemic and the winding up of globalization. A key factor in agricultural development, crop production, as well as related industries is the development of cultivated areas, especially in those regions that have poor climatic conditions. The use and expansion of sown areas is considered one of the factors of food security for the sustainable development of territories with a predominance of cold climate. The foundation is created for a stable agricultural market and less dependence on food products from other regions providing an increase in sown area. The development of this direction creates a certain control of the territories, the importance of which is significantly enhanced in the context of the ongoing processes of global warming and climate change. The development of this direction creates a certain control of the territories, the importance of which is significantly enhanced in the context of the ongoing processes of global warming and climate change. The paper presents the results of the analysis of the Republic of Karelia, Komi and Murmansk region. The sown areas of regions of different sizes were studied not only by absolute growth indicators, but also relative and average indicators were calculated to improve coverage of the state of the areas. A forecast for the medium-term development perspective was proposed, recommendations were formulated to ensure sustained development for the medium-term prospect in order to ensure food security and economic development of relevant territories.

1. Introduction
Agricultural development is a determining factor in ensuring food security of the territories in the context of the global pandemic and the collapse of globalization processes [1]. The development of cultivated areas, especially in those regions that have poor climatic conditions is a key factor in agricultural development, crop production, as well as related industries [2]. The use and expansion of sown areas, which is one of the factors of food security not only in the region, but also in the country as a whole, is considered for the sustainable development of territories with a predominance of cold climate. The basis is created for a stable agricultural market and less dependence on food products from other regions providing an increase in cultivated areas [3]. The development of this direction creates not only jobs, but also provides a certain “control” of territories, the importance of which is significantly enhanced in the context of ongoing global warming and climate change [4, 5, 6]. Existing technologies allow realizing the production of agricultural products in virtually any territory, but the definition of prospects, high-quality forecasting will contribute to the influx of investments and the development of relevant areas.
2. Problem statement
The problem of developing sown areas is one of the fundamental issues in the development of the agro-industrial complex in the context of the active development of regional sectors of the economy, the solution of which predetermines the dynamics of change and expansion of the production chain of food and other agricultural products [7]. Under existing conditions, the most acute problem is the development of cultivated areas of the northern regions, due to their sustainable food supply and support for the uniform development of the entire national economic complex of territories [8]. A detailed prognostic determination of the development trends of cultivated areas is important for determining the course of the crisis in the structural adjustment of the agrarian complex from the industrial to the post-industrial era [1]. The agricultural sector is one of the groups of industries that overcome changes in socio-economic conditions with most difficulty, and is most unstable when exposed to adverse external factors of globalization of agricultural markets in the existing world transformation processes [9].

3. Research questions
The processes of changing sown areas, their dynamics and fundamental trends in their development with the aim of subsequently determining the amount of land used by crop production and which is the basis for the agricultural sector during the development of the market economy of the Russian Federation in regions with cold agro-climatic conditions are the issues under study [10, 11]. It is possible to predetermine the state of the agroeconomy as a whole by determining the acreage [12]. A study of the dynamics of industries helps to determine the cycle of changes in the volume of areas depending on the influence of external factors of the country's socio-economic development [13].

4. Purpose of the study
The aim of the research is to study the dynamics of cultivated areas and develop a medium-term forecast for the northern regions to determine the state and development potential of the regional agricultural complex in the context of stimulating the development of agricultural sectors and ensuring food security in the territories. A number of the most representative northern territories were investigated to study the changes in each region separately in accordance with the stated goal.

5. Research methods
The work uses approaches based on the methods of trend analysis, which is one of the most important ways to study the processes occurring in agriculture [14]. A trend is determined by comparing each reporting position with a number of previous periods, that is, the main trend of the indicator’s dynamics, cleared of random influences and individual characteristics of individual periods [15]. A development trend is constructed with the highest determination coefficient using the graphical method [16]. The character of changes and the cyclical development of cultivated areas are formed through the mathematical analysis of the trend [17]. The nature of the trend and the values in the minimum and maximum values are determined using the values of the derivative and the second derivative to find key indicators and predict development [8]:

\[ y = ax^3 + bx^2 + cx + d, \text{ thousand ha} \]

\[ y_ka' = 3ax^2 + 2bx + c \]

where:
- \( x \) – time period from 1990 to 2025 at \( x \in [1] \)
- we equate the derivative function to zero and determine the values:
  \[ 3ax^2 + 2bx + c = 0 \]
  then \( x_1 = s \) and \( x_2 = l \)
- and define the second derivative to determine the truth and nature of the extremum (min and max):
  \[ y_ka'' = 6ax + 2b \]
Arithmetic mean values for the studied and forecasted periods were used in the process of writing the work in order to carry out medium-term forecasting of key indicators, as well as the average shares of these periods, relative and absolute growths. The presented representation combination option gives the best and most visible result.

6. Findings

The development of cultivated areas of the Far North is a complex and highly costly process compared to other regions of the country, but it is important to study the dynamics of the main production fund of crop production taking into account the strategic importance of the northern regions. It is necessary to determine the cyclical development and to determine the nature of the development of cultivated areas of the regions [13]. We will begin a review from the Komi Republic to ensure high-quality research results.

The Komi Republic is one of the largest regions of the district, being the northern region with significant costs for the production of agricultural products and maintenance of sown areas. It is necessary to conduct a trend analysis of the indicator dynamics in the period from 1990 to 2019 (figure 1).

![Figure 1. Dynamics of cultivated areas of the Komi Republic in 1990-2019, thousand hectares.](image)

The dynamics of the cultivated areas of the Komi Republic has a non-linear polynomial nature of development, which determines the cyclical nature of changes in the volume of cultivated areas depending on the time period. It is necessary to determine the nature of the trend and determine the values in the minimum and maximum values using the values of the derivative and the second derivative:

\[ Y_{ka}'' = 6ax + 2b \quad \text{at} \quad x \in [1] \]

where:
\[ Y_{ka}'' = 0.0104x^3 - 0.4235x^2 + 1.3876x + 101.45, \text{thousand ha} \]

We equate the derivative function to zero and determine the values:

\[ Y_{ka}' = 0.0312x^2 - 0.847x + 1.3876 \]
0.0312x^2-0.847x+1.3876=0

then \( x_1 = 1.751 \) and \( x_2 = 25.396 \)
and define the second derivative to determine the truth and nature of the extremum (min and max):

\[
y_{ko}'' = 0.0624x-0.847
\]

\[
y_{ko}'' = 0.0624*1.751-0.847 \text{ at } x_{ko}'' = 0.7377 \text{ the function changes sign from negative to positive, which indicates } x_1, \text{ max}(y_{ko}) \text{ and } x_2, \text{ mix}(y_{ko}).
\]

The derived high value of \( R^2 \) means a high probability of the development, according to the trend, of the cultivated area in the republic. An increase in the indicator is observed until 1991 (to 102.637 thousand ha) and from 2015 to the present, a decrease in the indicator was observed from 1992 to 2014 (to 33.895 thousand ha). The change over the period amounted to 63.44 thousand ha (a decrease of 63.11%), which is significant and predetermines the passage of the structural crisis in the region’s industry. The crisis has passed faster than in the Republic of Karelia, but with large losses of sown areas. The share of sown areas of the republic is insignificant relative to other areas of the regions of the NWFD for the period with a value of 2.89% (64.37 thousand ha). There is a need to make a forecast, according to the development trend of the indicator for a five-year period (table 1).

| Year | 2020  | 2021  | 2022  | 2023  | 2024  | 2025  |
|------|-------|-------|-------|-------|-------|-------|
| \( x \) | 31    | 32    | 33    | 34    | 35    | 36    |
| \( y \) | 47.3085 | 52.9764 | 59.7941 | 67.824 | 77.1285 | 87.77 |

It is possible to observe a significant increase in cultivated areas during the period by 136.70% according to the forecast data (50.69 thousand ha) with an average value for the period of 65.47 thousand ha and a share of 3.67% of all cultivated areas. A study of the dynamics of the industry showed that the growth in the district structure is high, but it is insignificant for the development of the industry and has a role only for the intra-regional market, but with the potential for the district market in the long term.

We will present data on the Murmansk region as the most north-western territory of the country to ensure the comprehensiveness and possibility of verification based on the presented theoretical calculations and the given forecast values.

The Murmansk region, being a border region, and one of the most unfavorable areas for crop production in the district, also requires determining the development trend of cultivated areas to identify changes in the main agricultural resource (figure 2).

The dynamics of sown areas of the Murmansk region has a nonlinear polynomial character of development, which determines the cyclical nature of the change in the sown area depending on the time period. It is necessary to determine the nature of the trend and determine the values in the minimum and maximum values, using the values of the derivative and the second derivative to determine the peak and crisis of the indicator:

\[
Y_{mr}''=-0.0014x^3+0.1071x^2-2.6853x+29.393, \text{ thousand ha} \tag{2}
\]

\[
Y_{mr}'''=-0.0042x^2+0.2142x-2.6853
\]

where:
\( x \) – time period from 1990 to 2025 at \( x \in [1] \)
we equate the derivative function to zero and determine the values:

\[-0.0042x^2+0.2142x-2.6853=0\]

then \( x_1 = 22.2 \) and \( x_2 = 28.8 \)
and define the second derivative to determine the truth and nature of the extremum (min and max):

\[
y_{mr}'''=-0.0084x+0.2142
\]
The dynamics of sown areas of the Murmansk region has a nonlinear polynomial character of development, which determines the cyclical nature of the change in the sown area depending on the time period. It is necessary to determine the nature of the trend and determine the values in the minimum and maximum values, using the values of the derivative and the second derivative to determine the peak and crisis of the indicator:

\[ Y_{mr} = -0.0014x^3 + 0.1071x^2 - 2.6853x + 29.393, \text{ thousand ha} \]  

(3)

where:

\( x \) – time period from 1990 to 2025 at \( x \in [1] \)

we equate the derivative function to zero and determine the values:

\[-0.0042x^2 + 0.2142x - 2.6853 = 0 \]

then \( x_1 = 22.2 \) and \( x_2 = 28.8 \)

and define the second derivative to determine the truth and nature of the extremum (min and max):

\[ y_{mr}'' = -0.0084x + 0.2142 \]

\[ y_{mr}'' = -0.0084*22.2 + 0.2142 \text{ at } x_1 \]

\[ y_{mr}'' = -0.0084*28.8 + 0.2142 \text{ at } x_2 \]

the function changes sign from negative to positive, which indicates \( x_1 \min(y_{mr}) \) and \( x_2 \max(y_{mr}) \).

A high value of \( R^2 \) means a high probability of the development, according to the trend, of the cultivated area in the region. An increase in the indicator is observed from 2012 to 2018 (up to 7.446 thousand ha) and a decrease in the indicator was observed from 1990 to 2011 (up to 7.245 thousand ha) and from 2019 to the present [18]. The change over the period amounted to 17.92 thousand hectares (a decrease of 72.35%), which is significant and determines the overcoming of the structural crisis in the region’s industry with the entry into a new recession period [5]. In order to prevent the implementation
of negative processes, measures should immediately be taken to stimulate the development of relevant sectors of the economy.

7. Conclusion
In conditions of reorientation of the economy to integrated territorial development, it requires active measures not only to introduce the achievements of scientific and technical progress in agricultural processes, but also active development, expansion of cultivated areas of the northern regions. The development of cultivated areas is uneven for the regions; changes in dynamics and share have multidirectional trends, which indicates a significant difference in overcoming the crisis in the current and subsequent periods [1]. The Republic of Karelia has sustainable development, having an insignificant share of sown area relative to other areas of the regions of the NWFD for the period and a stable position in the structure [11]. Studies have shown that significant growth is observed in the eastern regions with a significant restoration of the share of sown areas, which contributes to the formation of a stable, self-sufficient market for the main production fund of crop production. The main problems in the development of the most northern regions with a preserved negative trend in the dynamics of sown areas with their disappearance in the Nenets district in the long term [16]. In the Murmansk region, the crisis of structural adjustment of agriculture was successfully overcome, but the reduction in the current crop area indicates the onset of a new agrarian crisis, the overcoming of which at the moment should be a key task of the regional government.

It is important to apply a whole range of measures to support agricultural producers in these regions to achieve the level of land development during the Soviet economy and create a socially significant direction in ensuring the functioning and development of territories to overcome the crisis trends in the cultivation of sown areas, which will ensure the stability of the food market in these regions and the successful progressive development of the whole agro-industrial complex as a whole [15]. The yield forecasts presented in this work should be used in the processes of developing incentive measures for the development of the respective territories, which is especially important in the process of reorienting the economy in connection with the global pandemic and ensuring national food security for the medium and long term.

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