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# Monitoring and Forecasting the Development of Local Food Systems: A Case Study

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***Abstract:***

*The motivation of this research is the need to explore the role of a local food system in solving the problem of food security.*

*The article develops the methods for analyzing the current state of a food system and forecasting the future development of food markets. The methods and techniques have been tested for the food system in the Krasnoyarsk Territory.*

*The current trends in food supply chains in specific sectors (potatoes and vegetables, meat and milk, eggs and cereal products) have been highlighted for this region. The problems and the possible solutions have been identified. The medium-term and long-term consumption prospects offer opportunities for an in-depth study of the promising areas in the food industry of the region.*

***Keywords:*** *Food markets, food security, food systems, forecasting, monitoring.*

***JEL Classification:*** *J28, Q18.*

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## 1. Introduction

Food security is one of the global problems of modern society. Many countries have achieved success in the problem of food availability to the population, and at the world level, a significant progress has been made in reducing the rate of hunger. However, one of nine people of the world population still suffers from chronic malnutrition, half a billion people are obese, and one third of all food produced never reaches consumers (Jennings, 2015). There are significant disparities in subsistence support in the world (Food and Agriculture Organization of the United Nations, 2016). The main causes are: population growth, climate change, interregional conflicts and the differentiation of socio-economic development of countries (Garnett, 2013; Wheeler and Von Braun, 2013; Sidorenko and Mikhailushkin, 2012; Paptsov, 2015; Okunev et al., 2016). Therefore, there is a growing role of local food systems in the global subsistence support system (Tkach and Nechitailov, 2013; Allen, 2010; Trjascin, 2013; Erastova 2016; Bashmakov *et al.*, 2015).

A food system is all the processes of food production and commodity distribution infrastructure, which delivers foodstuffs to end-consumers. A food system unites all processes in the chain "agricultural products – consumption of finished food products" in a single way. It reflects the results of joint action of actors (producers, processors, resellers and consumers) within the general infrastructure of the food market and the movement of food, as well as the related socio-economic and environmental factors (Ericksen, 2008; Ericksen *et al.*, 2010; Ingram, 2011). The report (Food and Agriculture Organization of the United Nations, 2017) indicates that achieving the goal of zero hunger depends on the formation and harnessing of the potential of food systems. The effective use of this potential is possible in connecting cities, towns and their surrounding rural areas into a single chain of needs and the development of the agro-industrial sector and infrastructure, including active government policy and mixed investments.

The Russian practice of regulation and development of food systems is based on the concept of the state food security. The term of food security adopted in the Russian Federation differs from the interpretations of foreign authors. It is based on the sustainable domestic production of foodstuffs in the established normative volumes of its share in commodity resources of the domestic market for relevant products (Decree of the President of the Russian Federation No. 120, 2010). The primary purposes of the regional authorities for the food system development are:

(a) the implementation of a unified state policy for food security;
(b) the formation and support of the necessary food supply in the region;
(c) monitoring of food security in the region (Tyutyunik, 2016).

The main fields of food systems development are: promoting effective demand, support for domestic food producers and creating conditions for the organization of

wholesale and retail trade (Ulezko and Pashina, 2013). The key global factors affecting the regional food market are:

- urbanization and concentration of demand for food in the cities;
- change in the ration of the population;
- intensification of agricultural production technologies;
- introduction of new forms and methods of trade;
- transformation of food systems (Reardon and Timmer, 2014).

A purpose of this research is to determine the potential and the fields of development of regional food systems in the Russian Federation. To achieve the purpose, the methods for monitoring of processes in the regional food market and determining the long-term development trends are required. An object of this research is a regional food system of an industrial and agrarian region. An industrial and agrarian region is a region, in which industrial production is developed, but there are significant resources (arable land, pastures and water sources) to produce agricultural products. A typical representative of such a region is the Krasnoyarsk Territory. This region can become a center for interregional food system concentrating the proceeds of industrial production and redistributing them into the rural sector.

## 2. Methods and methodology

The procedures for obtaining the results can be divided into two parts: (1) monitoring and evaluation of contemporary processes in a food system; (2) scenario modeling and forecasting development scenarios.

### 2.1 Methods for monitoring and evaluation

When evaluating the development potential of a food system, we offer to analyze the processes in the markets for certain products. The processes being evaluated are: subsistence support, dependence on imports, export potential and the dynamics of market equilibrium. To obtain the data, we formed a set of the following coefficients: The correlation coefficient of the energy value of the ration ($C_E$) is:

$$C_E = \frac{E_{fact}}{E_{norm}} \quad (1)$$

Where:
$E_{fact}$ is the factual energy value of the ration per capita, kJ;
$E_{norm}$ is the recommended energy value of the ration in accordance with the natural climatic zone, kJ.
Value $C \leq 0.75$ is the unsatisfactory level of the energy value of the ration; $0.76 < C < 0.9$ – allowable level; $0.9 < C < 1.1$ – high level.

The coverage coefficient of demand by local production ($C_{S/D}$) is:

$$C_{S/D} = \frac{S_i}{D_i} \quad (2)$$

Where:

$D_i$ is the regional demand of the population for the relevant product i =1...6 (1 – potatoes; 2 – vegetables; 3 – meat; 4 – milk and dairy products; 5 – eggs; 6 – bread and cereal products (macaroni, cereals), thousand tons;

$S_i$ is the production of the corresponding product by local producers, thousand tons.

This coefficient in the global dimension has no specific rule. Its value indicates the saturation of demand for the i-th product at the expense of own production. For the Russian Federation, in accordance with the Food Security Doctrine and the operating principles of the regional food policy, it is possible to select estimates of normative values. For potatoes – $C_{S/D} \geq 0.95$; vegetables – $C_{S/D} \geq 0.85$; meat – $C_{S/D} \geq 0.85$; milk and dairy products – $C_{S/D} \geq 0.9$; bread and cereal products – $C_{S/D} \geq 0.95$. The coefficient of rational subsistence support ($C_R$) is:

$$C_R = \left(\frac{R_i}{Po}\right) \times \frac{1}{N_i} \quad (3)$$

Where:

$R_i$ is the food resources (local production, product stocks from the previous periods, import of products) for the relevant product, thousand tons;

Po is the population size of the region, thousand persons;

$N_i$ is the physiological norms of rational consumption of the product i, kg (pieces) (Order of the Ministry of Health of the Russian Federation No. 614, 2016);

$C_R=1$ is the normative value; $C_R=1$ means that there are threats to subsistence support in the region; $C_R>1$ is the availability of food stocks and the possibility of increasing the export of the corresponding product from the territory of the region.

The level of subsistence support of the region with products of own production in the consumption of the product in accordance with the physiological rational norms (Lv) is:

$$Lv_i = \frac{S_i - Po \times N_i}{S_i} \quad (4)$$

Where:

$Lv_i<0$ means that the local production is not able to fully provide the market in the rational structure of food consumption; $0<Lv_i<0.1$ – the local production is able to provide the market in the rational consumption structure; $Lv_i>0.1$ – the local production has a potential to increase exports. The coefficient for market equilibrium for product (C) is:

$$C_i = \frac{D_i + ID_i + L_i}{S_i + Im_i} \quad (5)$$

Where:

$ID_i$ is the productive consumption of the relevant product (for livestock feed, seeds, as raw materials for other industries), thousand tons;
$L_i$ is the loss of the product i in turnover, thousand tons;
Im is the food products' import, thousand tons;
C<1 means that the demand is less than the supply, there is excess production and a need to stimulate sales and export outside the territory;
C>1 – accordingly, the demand is larger than the supply; there is a shortage and a need to stimulate the inflow of food into the region.

The coefficient of external turnover ($C_T$) is:

$$C_T = \frac{Ex_i + Im_i}{S_i} \quad (6)$$

Where:
Ex is the exports of the product i from the territory of the region, thousand tons;
$C_T$<0.3 indicates low intensity of turnover of the studied food system with other food systems; 0.3< $C_T$<0.6 indicates an average intensity of turnover; $C_T$>0.8 –active interregional turnover.

The coefficient of price spread for the product is:

$$C_{SP} = \frac{P_{max}}{P_{min}} \quad (7)$$

Where:
$P_{max}$ is the maximum price for 1 kg of product, rub.; $P_{min}$ is the minimum price for 1 kg of product, rub.

The value of the coefficient in the interval 1-1.3 indicates the normal level of the price ratio. If the value is above 1.3, then there is lack of proportion in the trade infrastructure. Also, this value can indirectly indicate the presence of counterfeit and low-quality goods in the market.

### 2.2 Methods for forecasting and evaluating the development prospects

The procedure for obtaining the forecast has been carried out by the following algorithm:
*2.2.1 Step 1.* The forecast of the annual consumption of food products per capita by the following authors' regression models is:

$$\begin{cases} d_p = a_p + b_{1p} \times M_{In} + b_{2p} \times \frac{P_p}{P_{G2}} + b_{3p} \times \frac{P_p}{P_{G4}} + b_{4p} \times \frac{P_p}{P_{G1}} \\ d_v = a_v + b_{1v} \times M_{In} + b_{2v} \times \frac{P_{G31}}{P_{G4}} + b_{3v} \times \frac{P_{G31}}{P_{G2}} + b_{4v} \times \frac{P_{G31}}{P_{G1}} + b_{5v} \times \frac{P_{G31}}{P_{G1}} \\ d_b = a_b + \times M_{In} + b_{1b} \times \frac{P_{G4}}{P_{G3}} + b_{2b} \times \frac{P_{G4}}{P_{G2}} + b_{3b} \times \frac{P_{G4}}{P_{G7}} + b_{4b} \times \frac{P_{G4}}{P_{G1}} \\ d_m = a_m + b_{1m} \times M_{In} + b_{2m} \times \frac{P_{G2}}{P_{G1}} + b_{3m} \times \frac{P_{G2}}{P_{G3}} + b_{4m} \times \frac{P_{G2}}{P_{G7}} \\ d_{meat} = a_{meat} + b_{1meat} \times M_{In} + b_{2meat} \times \frac{P_{G1}}{P_{G2}} + b_{3meat} \times \frac{P_{G1}}{P_{G3}} + b_{4meat} \times \frac{P_{G1}}{P_{G7}} \\ d_e = a_e + b_{1e} \times M_{In} + b_{2e} \times \frac{P_{G7}}{P_{G2}} + b_{3e} \times \frac{P_{G7}}{P_{G3}} \\ d_f = a_f + b_{1f} \times M_{In} + b_{2f} \times \frac{P_{G5}}{P_{G3}} + b_{3f} \times \frac{P_{G5}}{P_{G1}} \\ d_{fish} = a_{fish} + b_{1fish} \times M_{In} + b_{2fish} \times \frac{P_{G6}}{P_{G1}} + b_{3fish} \times \frac{P_{G6}}{P_{G2}} + b_{3fish} \times \frac{P_{G6}}{P_{G7}} \end{cases} \quad (8)$$

Where:
a, $b_1$, $b_2$ … are the parameters of regression equations.

The criterion (dependent) variable d is the annual consumption (demand) of the respective products (p – potatoes, kg; v – vegetables and cucurbitaceous crops, kg; b – bread and cereal products, kg; m – milk and dairy products (in milk fat content of 2.3-3%), kg; meat – meat and meat products (in meat), kg; e – eggs, pc; f – fruit, kg; fish – fish and fish products (in fish), kg);

*Predictors:*
$M_{In}$ is the growth rate of the real disposable income of the population, %;
G1 is the meat subgroup (beef, pork, chicken); $P_{G1}$ is the purchase price of three products: 1 kg of beef, 1 kg of pork and 1 kg of chicken;
G2 is the dairy subgroup; $P_{G2}$ is the purchase price of 1 liter of milk, 1 kg of sour cream and 1 kg of butter;
G3 is the vegetables and potatoes' subgroup; $P_{G3}$ is the purchase price of 1 kg of cabbage, 1 kg of carrots, 1 kg of potatoes and 1 kg of onions;
G31 is the vegetables' subgroup; $P_{G31}$ is the purchase price of 1 kg of cabbage and 1 kg of carrots;
G4 is the bread subgroup; $P_{G1}$ is the purchase price of 1 kg of flour, 1 kg of top-grade flour and 1 kg of buckwheat;
G5 is the fruit subgroup; $P_{G1}$ is the purchase price of 1 kg of oranges, 1 kg of apples and 1 kg of bananas;
G6 is the fish subgroup; $P_{G1}$ is the purchase price of 1 kg of fresh fish (except salmon breeds) and 1 kg of fresh-frozen fish;

G7 is the eggs' subgroup; $P_{G1}$ is the purchase price of 1 kg of cabbage, 1 kg of carrots and 1 kg of potatoes.

*2.2.2 Step 2.* The forecast of demand for foodstuffs in the region is:

$$D_{product} = d \times Po_{forecast} \quad (9)$$

Where:

$Po_{forecast}$ –is the predicted population size by the moderate scenario from the Ministry.

*2.2.3 Step 3.* The forecast of the need for products' import is:

$$Im_{forecast} = D - S_{forecast} \quad (10)$$

Where:

$Im_{forecast}$ is the forecast of demand for products' import, thousand tons; $S_{forecast}$ is the scenario volumes of food production in the region, thousand tons. These methods and techniques have been applied for the analysis of the food system in the Krasnoyarsk Territory.

## 3. Results and discussion

Monitoring of food security in the regions of the Russian Federation carried out by the authors (Parshukov *et al.,* 2017) has allowed identifying the region as a potential food producer with well-developed wholesale and retail chain, but with the problems in the transport infrastructure. The results of the current study are presented below.

### 3.1 The results of monitoring and evaluation of contemporary processes in the food system of the Krasnoyarsk Territory

Table 1 presents the calculated values for the coefficients of markets for different products. The values presented are averages for three years (2014-2016).

***Table 1.*** *Data of the monitoring processes in the food markets on average for 2014-2016.*

| Food markets | Coefficients | | | | | |
|---|---|---|---|---|---|---|
| | $C_{S/D}$ | $C_R$ | $L_V$ | C | $C_T$ | $C_{SP}$ |
| Market for potatoes | 2.11 | 7.75 | 0.77 | 0.94 | 0.04 | 1.25 |
| Market for meat and meat products | 0.59 | 1.28 | -0.57 | 0.92 | 1.01 | 1.45 |
| Market for milk and dairy products | 1.02 | 1.02 | -0.28 | 0.83 | 0.49 | 1.5 |
| Market for vegetables | 0.72 | 1.1 | -0.79 | 0.98 | 0.52 | 1.16 |
| Market for eggs | 1.16 | 1.29 | 0.083 | 0.79 | 0.4 | 1.16 |
| Market for bread and cereal products | 0.83 | 1.12 | -0.37 | 0.98 | 0.47 | 1.25 |

*The market for potatoes:* The potatoes production by several times exceeds the needs of the market ($C_{S/D}$>1). Own production allows providing the population and industrial consumption ($C_R$>1). There is a significant potential for export and deep processing of potatoes (Lv>0.3). Now, this potential is used very poorly as indicated by a low level of interregional turnover (coefficient $C_T$ – 0.04). The level of the price ratio is within the normal range. The promising directions of the potatoes market development are: support of processes for the organization of potatoes deep processing; the promotion of potatoes exports and the organization of potatoes storages.

*The market for milk:* The opportunities for local production under the current consumption model in the region allow meeting the demand ($C_{S/D}$>1). In the consumption of dairy products per capita within the rational norm, the current volume of local production will be insufficient ($L_V$<0). But the value of $C_R$>1 indicates that the total volume of food resources (production, imports and stocks) in milk allows providing the consumption volumes in physiological norms. The value of $C_T$ coefficient indicates the average intensity of dairy products' turnover with other regions. The price spread is above the norm indicating imbalances in the trade infrastructure. The priority areas for the market development are: support of local businesses, stimulation of increasing livestock in the Krasnoyarsk Territory and subsidizing of costs for milk processing.

*The market for meat and meat products:* The coefficient for market equilibrium (C) indicates that the demand is less than the supply, and the population is provided with meat products within the current consumption. The food resources of the market allow meeting the current needs and consumption within the physiological norm. But the local production is insufficient to meet the demand ($C_{S/D}$<1, $L_V$<0). These processes and the high price spread create the conditions for import of meat products, however, not always of good quality. The priority directions are: the fight against adulteration of meat products in the market, support of local production and stimulating demand for local products.

*The market for vegetables:* The current volume of all vegetable products (own and imported) in the market provides both the established and rational norms of consumption ($C_R$>1). Provision of the current consumption with own production is 72% ($C_{S/D}$). The coefficient for market equilibrium indicates that the demand is less than the supply and the market is saturated. But own production is not enough to cover consumption within the rational physiological norm. Additionally, it should be noted that about 40% of local products are produced in households, for which the effective support mechanisms have not been developed yet. The priority areas of the market development are: the development of measures to support the vegetables' production in households, the organization of vegetable logistic distribution centers and vegetable stores, the development of consumer cooperatives in rural areas and subsidizing vegetable-growing enterprises.

*The market for eggs:* The current consumption volumes of eggs can be satisfied through own production ($C_{S/D}>1$). The volumes of eggs in the food market (import and own production) are sufficient to meet the demand within the rational norm of consumption. The coefficient of market equilibrium indicates the excess of the supply over the demand, and there is a potential either to increase exports or to reduce the volumes of imported commercial eggs. The price spread is within the normal range. The market for eggs is a stable element in the food system of the region. The main directions of development are: the creation of economic conditions for the production growth and products' exports to other regions.

*The market for bread and cereal products:* The Krasnoyarsk Territory is a net exporter of cereals. But only 66% of cereals are the food ones. The flour manufacture is poorly developed. Therefore, most of the flour comes from the Altai Territory and the Novosibirsk Region. Own production is not able to meet the current demand ($C_{S/D}<1$). But there are no problems in food supply of the population with products ($C_R>1$). The price spread is within normal range. The perspective directions of development are: the organization of the flour, cereals and feed milling companies in mastering the production and processing of wheat, oats and barley.

The general conclusion of the conducted analysis is as follows. The food market of the Krasnoyarsk Territory is provided with food products in the required quantities, and the population has no food shortages. As for milk, eggs and potatoes, the local producers can cover demands within the existing food structure. However, there is a shortage of own production of vegetables and meat. The main problem in the medium-term period is the reduction in real incomes of the population, which leads to the reduced quality of food consumed.

### 3.2 The forecast of consumption, production and need for food products' import for the Krasnoyarsk Territory

To conduct the forecast, three scenarios have been developed: negative, moderate and positive. The values of the scenarios parameters have been defined based on the results of the analysis for the retrospective period from 1998 to 2016. The parameters of the negative scenario have been determined based on the values in the periods of economic crises in the economy of the Russian Federation and the Krasnoyarsk Territory: 1998-1999, 2008-2010 and 2014-2015 (KRASSTAT, 2016; ROSSTAT, 2016).

The parameters of the moderate scenario have been determined based on the values in the post-crisis periods (2000-2007, 2010-2013). The parameters of the positive scenario have been determined based on the best values for the entire study period from 1998 to 2016. The forecast of the population size has been chosen by the moderate variant of demographic projection (KRASSTAT, 2015). The description of the scenarios is presented in Table 2.

***Table 2.*** *The description of the scenarios for forecasting.*

| Scenario parameter | Negative scenario | Moderate scenario | Positive scenario |
|---|---|---|---|
| The growth rate of production in the region | | | |
| Vegetables and cucurbitaceous crops | 0% | 3% | 5% |
| Meat of livestock and poultry | -1% | 2% | 5% |
| Milk | -1% | 3% | 5% |
| Eggs | 0% | 3% | 5% |
| The growth rate of incomes of the population | -2% per year until 2020 | 1% per year until 2020 | 2% per year until 2020 |
| | -1.5% per year until 2025 | 1.5-2% per year until 2025 | 3-3.5% per year until 2025 |
| | -1% per year until 2030 | 3% per year until 2030 | 4-5% per year until 2030 |
| Inflation in the food groups | | | |
| G1 – meat subgroup | 3% per year until 2020<br>3.5-4% until 2025<br>4-5% per year until 2030 | 1-1.5% per year until 2020<br>1.5% until 2025<br>1-2 % per year until 2030 | 0-0.5% per year until 2020<br>0.5-1% until 2025<br>1% per year until 2030 |
| G2 – milk and dairy products' subgroup | 4% per year until 2020<br>5% until 2025<br>5-5.5 % per year until 2030 | 1-2% per year until 2020<br>2.5% until 2025<br>2-2.5 % per year until 2030 | 1% per year until 2020<br>1-1.5% until 2025<br>1-2 % per year until 2030 |
| G3 – vegetables and potatoes subgroup | 2% per year until 2020<br>2.5-3% until 2025<br>4-5% per year until 2030 | 1% per year until 2020<br>1.5-2% until 2025<br>2% per year until 2030 | -0.5-0% per year until 2020<br>0.5% until 2025<br>1% per year until 2030 |
| G4 – bread and cereals subgroup | 4% per year until 2020<br>4-4.5% until 2025<br>5% per year until 2030 | 2% per year until 2020<br>2-2.5% until 2025<br>2.5% per year until 2030 | 1.5-2% per year until 2020<br>2% until 2025<br>2.5% per year until 2030 |
| G5 – fruit subgroup | 5% per year until 2020<br>4.5-5% until 2025<br>6% per year until 2030 | 2.5% per year until 2020<br>3% until 2025<br>3.5% per year until 2030 | 2% per year until 2020<br>3% until 2025<br>4% per year until 2030 |
| G6 – fish subgroup | 3% per year until 2020<br>3.5-4% until 2025<br>4-5% per year until 2030 | 1% per year until 2020<br>1.5-2% until 2025<br>1-3% per year until 2030 | 1-1.5% per year until 2020<br>1.5% until 2025<br>2% per year until 2030 |

| | | | |
|---|---|---|---|
| G7 – eggs subgroup | 1% per year until 2020<br>1.5-2% until 2025<br>2-2.5% per year until 2030 | 1% per year until 2020<br>1-1.5% until 2025<br>1.5% per year until 2030 | -0.5-0% per year until 2020<br>0.5% until 2025<br>1% per year until 2030 |
| Population size | | | |
| 2018 | 2,881,447 people | | |
| 2019 | 2,887,499 people | | |
| 2020 | 2,892,314 people | | |
| 2025 | 2,911,559 people | | |
| 2030 | 2,916,923 people | | |

The econometric models for forecasting of food consumption per capita per year for the Krasnoyarsk Territory:

a) The model for forecasting potatoes' consumption per capita per year in the Krasnoyarsk Territory:

$$d_p = 190.018 - 0.06 \times M_{In} + 14.87 \times \frac{P_p}{P_{G2}} - 0.338 \times \frac{P_p}{P_{G4}} + 9.359 \times \frac{P_p}{P_{G1}}$$

$$r = 0.93; r^2 = 0.85; F = 13.47$$

b) The model for forecasting vegetables consumption per capita per year in the Krasnoyarsk Territory:

$$d_v = 55.614 + 0.62 \times M_{In} - 47.63 \times \frac{P_{G31}}{P_{G4}} - 232.21 \times \frac{P_{G31}}{P_{G2}} - 397.69 \times \frac{P_{G31}}{P_{G1}} + 44.94 \times \frac{P_{G31}}{P_{G1}}$$

$$r = 0.87; r^2 = 0.76; F = 5.23$$

c) The model for forecasting bread and cereal products' consumption per capita per year in the Krasnoyarsk Territory:

$$d_b = 110.48 + 0.08 \times M_{In} + 2.64 \times \frac{P_{G4}}{P_{G3}} + 73.38 \times \frac{P_{G4}}{P_{G2}} - 0.79 \times \frac{P_{G4}}{P_{G7}} - 82.47 \times \frac{P_{G4}}{P_{G1}}$$

$$r = 0.89; r^2 = 0.8; F = 6.86$$

d) The model for forecasting milk and dairy products' consumption per capita per year in the Krasnoyarsk Territory:

$$d_m = 173.01 - 0.022 \times M_{In} + 50.47 \times \frac{P_{G2}}{P_{G1}} - 0.00049 \times \frac{P_{G2}}{P_{G3}} + 14.51 \times \frac{P_{G2}}{P_{G7}}$$

$$r = 0.86; r^2 = 0.74; F = 6.55$$

e) The model for forecasting meat and meat products' consumption per capita per year in the Krasnoyarsk Territory:

$$d_{meat} = 55.86 + 0.247 \times M_{In} - 48.02 \times \frac{P_{G1}}{P_{G2}} - 1.53 \times \frac{P_{G1}}{P_{G3}} + 3.32 \times \frac{P_{G1}}{P_{G7}}$$

$$r = 0.9; r^2 = 0.81; F = 9.68$$

f) The model for forecasting eggs consumption per capita per year in the Krasnoyarsk Territory:

$$d_e = 220.49 + 0.557 \times M_{In} - 2.027 \times \frac{P_{G7}}{P_{G2}} - 429.26 \times \frac{P_{G7}}{P_{G3}}$$

$$r = 0.786; r^2 = 0.61; F = 5.39$$

g) The model for forecasting fruits consumption per capita per year in the Krasnoyarsk Territory:

$$d_f = 141.94 - 0.278 \times M_{In} - 6.495 \times \frac{P_{G5}}{P_{G3}} - 153.28 \times \frac{P_{G5}}{P_{G1}}$$

$$r = 0.81; r^2 = 0.65; F = 6.4$$

h) The model for forecasting fish consumption per capita per year in the Krasnoyarsk Territory:

$$d_{fish} = 8.4 + 0.085 \times M_{In} - 41.63 \times \frac{P_{G6}}{P_{G1}} - 45.62 \times \frac{P_{G6}}{P_{G2}} + 5.65 \times \frac{P_{G6}}{P_{G7}}$$

$$r = 0.91; r^2 = 0.82; F = 10.53$$

R is the overall correlation coefficient;
$r^2$ is the determination coefficient;
F is the overall Fisher coefficient.

The long-term forecast of food consumption per capita according to the models is presented in Table 3.

***Table 3.*** *The long-term forecast of food consumption per capita for the Krasnoyarsk Territory*

| Products | Scenarios | Year of forecast | | |
|---|---|---|---|---|
| | | 2020 | 2025 | 2030 |
| Potatoes, kg | Negative | 184.41 | 185.36 | 187.16 |
| | Moderate | 182.32 | 181.64 | 181.30 |
| | Positive | 181.46 | 179.94 | 178.98 |
| Vegetables and cucurbitaceous crops, kg | Negative | 113.09 | 112.54 | 111.72 |
| | Moderate | 114.23 | 116.91 | 121.36 |
| | Positive | 118.14 | 119.94 | 122.61 |
| Bread and cereal products, kg | Negative | 113.64 | 114.56 | 115.54 |
| | Moderate | 112.86 | 112.99 | 112.65 |
| | Positive | 112.87 | 112.95 | 113.13 |
| Meat and meat products, kg | Negative | 72.43 | 72.25 | 71.79 |
| | Moderate | 73.19 | 72.89 | 74.24 |
| | Positive | 74.15 | 74.61 | 75.33 |
| Milk and dairy products, kg | Negative | 248.73 | 248.75 | 248.77 |
| | Moderate | 247.66 | 250.21 | 254.88 |
| | Positive | 249.56 | 251.66 | 253.64 |
| Eggs, pieces | Negative | 247.18 | 246.38 | 244.34 |
| | Moderate | 250.68 | 253.34 | 256.39 |
| | Positive | 253.87 | 256.74 | 259.64 |
| Fruit, kg | Negative | 42.34 | 42.27 | 41.96 |

| | | | | |
|---|---|---|---|---|
| | Moderate | 51.64 | 50.00 | 46.23 |
| | Positive | 53.83 | 53.05 | 54.12 |
| Fish and fish products, kg | Negative | 17.82 | 17.86 | 17.82 |
| | Moderate | 17.77 | 17.87 | 18.91 |
| | Positive | 18.76 | 18.85 | 19.46 |

The negative scenario is: a decrease in the consumption of protein products (milk, meat and fish) and healthy carbohydrates (vegetables and cereal products), an increase in the consumption of potatoes and bread products in the specified limits. The moderate scenario is: a slight increase in the consumption of protein products and healthy carbohydrates, the consumption of fruits and potatoes will be reduced. The positive scenario assumes an approximation of the ration to the rational physiological consumption norms. The calculation of how these trends will affect the region's needs in food imports in the medium-term period is presented in Table 4.

***Table 4.*** *The medium-term forecast of production and the need for food products' import for the Krasnoyarsk Territory.*

| Product groups | Scenario | Year of forecast | | |
|---|---|---|---|---|
| | | 2018 | 2019 | 2020 |
| Food production in the Krasnoyarsk Territory, thousand tons/million pieces | | | | |
| Milk and dairy products (in recalculation for milk of established fat content) | Negative | 732.40 | 725.08 | 717.83 |
| | Moderate | 761.99 | 784.85 | 824.10 |
| | Positive | 776.79 | 815.63 | 856.41 |
| Meat (including byproducts) and meat products (in slaughter weight) | Negative | 123.65 | 122.41 | 121.19 |
| | Moderate | 127.40 | 129.95 | 132.54 |
| | Positive | 131.15 | 137.70 | 144.59 |
| Vegetables and cucurbitaceous crops | Negative | 225.30 | 225.30 | 225.30 |
| | Moderate | 232.06 | 239.02 | 246.19 |
| | Positive | 236.57 | 248.39 | 260.81 |
| Eggs (million pieces) | Negative | 814.00 | 814.00 | 814.00 |
| | Moderate | 838.42 | 863.57 | 889.48 |
| | Positive | 854.70 | 897.44 | 942.31 |
| Bread and cereal products, kg | Negative | 327.45 | 330.10 | 332.92 |
| | Moderate | 325.88 | 326.26 | 325.28 |
| | Positive | 326.46 | 326.69 | 327.21 |
| The need for food products' import into the Krasnoyarsk Territory, thousand tons/million pieces | | | | |
| Milk and dairy products (in recalculation for milk of established fat content) | Negative | -15.70 | -6.87 | 1.58 |
| | Moderate | -48.37 | -69.73 | -107.79 |
| | Positive | -57.70 | -95.03 | -134.60 |
| Meat (including byproducts) and meat products (in slaughter weight) | Negative | 96.58 | 98.28 | 99.87 |
| | Moderate | 95.02 | 92.94 | 90.72 |
| | Positive | 96.93 | 90.85 | 84.34 |
| Vegetables and cucurbitaceous crops | Negative | 100.56 | 101.25 | 101.79 |
| | Moderate | 97.09 | 90.82 | 84.20 |

| | | | | |
|---|---|---|---|---|
| | Positive | 103.85 | 92.74 | 80.89 |
| Eggs (million pieces) | Negative | -101.76 | -100.27 | -99.08 |
| | Moderate | -116.10 | -139.73 | -164.43 |
| | Positive | -123.19 | -164.39 | -208.04 |
| Bread and cereal products, kg | Negative | 55.67 | 52.88 | 47.39 |
| | Moderate | 52.14 | 41.57 | 29.20 |
| | Positive | 48.97 | 35.33 | 21.28 |

The need for imports of milk and dairy products in any scenario will disappear by 2020. There is also no need to import eggs in all variants of the situation development. In the positive scenario, the export potential for eggs in 2020 will reach 208 million units. At the same time, even with the increase in volumes of production of vegetables and meat by 5% per year (positive scenario) the need for imports will remain. In the negative scenario, the need for the import of meat and vegetables will be about 100 thousand tons per year.

## 4. Conclusion

In this research, we have assessed the opportunities and the prospects for the local food system in the Krasnoyarsk Territory in providing the local population with food products. It has been found out that the food markets of the region are saturated with food products. Own production covers the current demands for eggs, potatoes, milk and dairy products. The shortage of own production of meat, vegetables and flour is covered through the established supplies from other regions. The dependence on food imports in the medium-term prospect will not be solved even by an increase in own production up to 5% per year. The consumption of protein products and healthy carbohydrates will grow only with the growth of the population's real incomes of over 3-5% per year. In the market of meat and milk, there are growing threats of counterfeit products.

These conclusions are confirmed by the reports of the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing (2017). According to the inspection data, 90% of semi-finished meat products and over 50% of dairy products do not correspond to the declared quality. The markets of these products can be classified as markets with asymmetric information of G. Akerlof. The priority areas of the food system development in the Krasnoyarsk Territory are: supporting initiatives for deep processing of agricultural products, the development of consumer cooperatives in rural areas, the entry into circulation of agricultural land (arable land and pastures), the establishment of logistic hubs to optimize food flows and improving the quality control of food products. Our future research is the evaluation of the unrealized potential of own food production; the analysis of the placement of processing food facilities and the study of how the consumer behavior model in the region will change.

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