Potential of China’s Agricultural Resources

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Abstract. The calculation of the agricultural potential of China, based on the production of grains, oilseeds (inputs are arable and irrigation areas, fertilizers) and meat (inputs are grains, oilseeds, and oilseeds derivatives (meal) production), according to FAO and USDA statistics. Based on the analysis of the relationships of these parameters, a mathematical model is developed (a system of equations of multiple regression). Growth in yield of cereal crops up to 6.1 t/ha, oilseeds crop yield grow to 2.7 t/ha, the proportion of grain sent to livestock feed up to 60%, the share of irrigated land up to 60% are the main input parameters. In this case potential production of food products, in particular, grain crops and meat, is potentially sufficient for the self-supply of the population of China of 1,600 million people. An acute problem for China will remain to provide the population with meat products, which will require the import of oilseed meal. This scientific and methodological toolbox makes it possible to obtain an objective quantitative assessment of the potential regional population.

Introduction

Food production is one of the basic sectors of the national economy, on the capabilities of which the socio-economic situation and population growth substantially depend. Providing food security, taking into account external and internal threats, is a necessary condition for the economic security of the state. Prediction and regulation of the development of other industries and state economies is carried out taking into account the potential for agricultural development. The purpose of this paper is to analyze the potential and agricultural resources of China on the basis of the analysis of the dynamics and achievements of the agricultural sector from 1961 to 2017, using the available global statistics. The dynamics of the agricultural sector (crops production and meat) was estimated in China from 1961 to 2017 [4, 5]. The main grains and oilseeds for analysis were selected: barley, beans, buckwheat, corn for grain, millet, oats, rice, rye, sesame, sisal, sorghum, soy, sunflower, triticale and wheat.

Modeling the dynamics and factors of reproduction of the world population is widely represented in researchs: Haub C. [16], Lutz [20], Meadows D. [22], Mesarovic M. [19], Verhulst P.F. [6], Forrester J. [18], Volterra V. [7], Vishnevsky A.G. [17], Kapitsa S.P. [9], Kondratiev K.Ya. [1], Egorov et al. [8], Chechulin V.L. [12], Shorkin A.D. [13], Valentei D.I. [14].

The history of the development of agriculture was considered in isolation from the population, living in the period in question: Turchinovich [3], Mazoyer [21].

In these works, the dynamics of agricultural resources, crop yields and the state of agricultural technologies were not considered, which did not allow this to assess the resource potential.

Analysis of the agricultural development status in China from 1961 to 2017

According to the Foodand Agriculture Organization (FAO) [5] and United States Department of Agriculture (USDA) [6] (table 1) from 1961 to 2017, the area of arable land in China grew by 20 %. Irrigated land in China has traditionally occupied a large share of agricultural cultivated land - from 1961 to 2017, the area grew by 63%, and the share grew from 44% to 61%. The area of grain crops occupies 85% of the arable land, previously this figure was 90%. The development of the
agricultural complex of China since 1961 was characterized by an increase in the applied doses of mineral nitrogen fertilizers from 5.3 to 249.2 kg/ha and phosphorus fertilizers from 1.4 to 104.2 in 2017. The average high use of nitrogen fertilizers is mainly due to the development of growing vegetables, the area of which has grown from 5 to 24 million hectares, and production from 50 to 556 million tons.

Grain crop yields in China have the highest values in the world [6], however, due to the large population, the specific production rate per person of 380 kg/person is sufficient to fully satisfy the needs of all members of society for grain processing products, but not enough for growing and production of the required amount of meat (73 kg/person per year) [2].

The yield of oilseeds in China varies depending on the source of information: the FAO estimates 1.4 t/ha, but taking into account all oilseeds [6]. USDA shows that soybean yield 1.89 t/ha (below world 2.9 t/ha) and sunflower in the 2.6 t/ha (above the level of the global 1.96 t/ha) [5]. However, in China, the bioclimatic conditions for soybean cultivation are different from the US. In order to increase yields, development and introduction of regional zoned varieties should be developed.

Table 1. China agricultural statistics for Model.

| Variable Names                   | Units       | 1961 | 1990 | 2000 | 2005 | 2010 | 2017 |
|----------------------------------|-------------|------|------|------|------|------|------|
| Arable land                      | million ha  | 103.4| 124.5| 118.8| 112.9| 107.8| 119.5|
| Irrigation                       | million ha  | 45.2 | 50.2 | 54.2 | 62.3 | 66.7 | 73.7 |
| Cereals, area harvested          | million ha  | 90.6 | 93.6 | 85.6 | 82.2 | 90.1 | 102.8|
| Oilseeds, area harvested         | million ha  | 17.5 | 23.7 | 28.4 | 28.9 | 27.2 | 26.0 |
| Vegetables, area harvested       | million ha  | 5.0  | 6.9  | 16.0 | 19.3 | 21.2 | 24.0 |
| Vegetable production             | million tons| 50.2 | 117.9| 300.8| 370.7| 459.8| 556.7|
| Nitrogen Fertilizers             | kg/ha       | 5.3  | 157.1| 186.4| 237.7| 275.5| 249.2|
| Phosphate fertilizing            | kg/ha       | 1.4  | 47.0 | 72.5 | 103.1| 133.5| 104.2|
| Grain Harvesting Yields          | t/ha        | 1.0  | 3.6  | 4.0  | 4.5  | 4.8  | 5.3  |
| Cereals production               | million tons| 90.9 | 340.9| 344.1| 368.7| 432.2| 548.5|
| Cereals feed consumption         | million tons| 6.3  | 52.8 | 98.3 | 103.7| 140.7| 207.8|
| Oilseeds, yield                  | t/ha        | 0.4  | 0.9  | 1.1  | 1.2  | 1.3  | 1.4  |
| Oilseeds production              | million tons| 6.8  | 21.5 | 31.2 | 34.2 | 34.2 | 35.6 |
| Meal feed consumption            | million tons| 0.0  | 1.6  | 22.0 | 35.1 | 52.1 | 81.1 |
| Meat production                  | million tons| 2.5  | 29.9 | 61.9 | 71.1 | 81.1 | 88.2 |

Taking Russia as an example to establish a model to calculate the agricultural potential of China

For the calculation of the potential population of China on the basis of the estimate k biosc climatic potential of agriculture in the production e grains and oilseeds, plants and meat, sponsored by the example of Russia developed the forecast model [1, 3].

Cereals (60.5%) and oilseed meals (19.7%) together occupy more than 80% of the modern diet of livestock and poultry and are the main crops necessary for the nutrition of the population. A high protein content in meal (up to 50%) increases the nutritional value of feed and allows you to accelerate the cultivation of meat species of animals (for example, beef, pork) and poultry. In the world from 1961 to 2017 the share of oilseed meal in the diet of farm animals and poultry increased from 3% to 20% [1].

The estimation of the volume of production of grain and oilseeds is made on the basis of potential productivity, depending on the introduced nitrogen and phosphorus fertilizers, and the area of irrigated land. Meat production for the world and Russia was estimated based on the area of pastures and the use of grain and oilseeds and their derivatives (meal) for cattle and poultry feeding. For China, with a large import of oilseed meals and oilseeds, a production approach was used for
the average conversion of grain feed and high-protein feed based on oilseed meal: for grain feed, the conversion coefficient is 8 kg/kg (n*kg of feed in n*kg of meat) for oilseed meal 2 kg/kg.

This model does not take into account the economic and social living conditions of the population and the precession of climatic fluctuations. Evaluation is carried out solely on the possibility of providing the population with food—cereals, oilseeds, meat for the period from 1961 to 2017. Norma cereals in the human diet is taken as 100 kg/ person per year, the consumption of meat rate 73 kg/year based on Ministry of Health of the Russian Federation recommendations, with the norm of 96 kg of cereals in different forms—flour, pasta, etc. [2]. Verification of the model was carried out on world and regional statistics with a number of observations for 1961-2017, which made it possible to obtain preliminary results of assessing the potential of the agricultural sphere using the analysis of agriculture of the countries of the world and Russia [1, 3].

Calculation results of the biological tank China Agricultural complex, with the proviso increase yields of crops to 6.1 t/ha and oilseeds to 2.7 t/ha show that the population of China may be 1568.2 mln people, provided that people eat, according to the norm of the Ministry of Health of the Russian Federation: 100 kg per person per year of grain and 39.9 kg of meat per person per year. According to the FAO, the current consumption of meat per person per year in the world averages 44.2 kg [4].

For the calculation and Valuation agricultural potential for China following input received data: the area of land in the processing of 1 20 million. hectares of irrigated land area 73,7 million ha, grains and oilseeds 47,5 and 10 million ha, phosphorus fertilizers should be 150 kg/ha per year. This will increase the yield of grain to 6.1 t/ha (current 2.9 t/ha - in 2018) and oilseed yield to 3.7 t/ha (in 2018 - 1.4 t/ha). The system of equations is presented in table 2.

| Variables                        | Units          | N  | Equations                               |
|----------------------------------|----------------|----|-----------------------------------------|
| Arable land                      | million ha     | x1 | X1 = 0.6                                |
| Irrigation                       | million ha     | x2 | X2 = 0.86                               |
| Cereals, area harvested          | million ha     | x3 | X3 = 0.25                               |
| Oilseeds, area harvested         | million ha     | x4 | X4 = 0.25                               |
| Nitrogen Fertilizers             | kg/ha          | x5 | X5 = 0.25                               |
| Phosphate fertilizing            | kg/ha          | x6 | X6 = 0.25                               |
| Cereals yield                    | t/ha           | x6 | X6 = 0.25                               |
| Cereals production               | million tons   | x7 | X7 = X5 * X6                            |
| Cereals feed consumption         | million tons   | x8 | X8 = 0.6                                |
| Cereals seed                     | million tons   | x9 | X9 = 0.04                               |
| Cereals ending stocks            | million tons   | x10| X10 = 0.25                              |
| Oilseeds yield                   | t/ha           | x11| X11 = 0.0019 + X5 * 0.0024 + 0.481     |
| Oilseeds production              | million tons   | x12| X12 = X11 * X4                          |
| Oilseed meal production          | million tons   | x14| X14 = (X12 - X11) * 0.5                 |
| Meal feed consumption            | million tons   | x15| X15 = 0.86                              |
| Meat production                  | million tons   | x16| X16 = 0.125 + X15 * 0.5                 |
| Cereals food cons.               | million tons   | X20| X20 = X7 - X8 - X9 - X10                |
| Meat food cons.                  | million tons   | X16|                                        |
| Cereals per capita               | kg/per year    | X17|                                        |
| Meat per capita                  | kg/per year    | X18| X18 = X16 * 1000/X19                    |
| Population estimate             | Millions people| X19| X19 = (X7 - X8 - X9 - X10) * 1000/X17   |
Results and findings

According to the obtained model, the main problems of Chinese agriculture are the yield of grain crops (the main crop for nutrition), oilseeds (necessary for animal and bird fattening) and the proportion of grain crops used for animal nutrition.

Currently, 38% of grain crops are sent to China for cattle and poultry fattening, the world average is 50%, with meat supplying 44.5 kg/person per year [1]. With an increase in the yield of grain crops to 6.1 tons/ha, 2.8 billion people can be fed for grain, with meat consumption 17.1 kg/person per year (option 1) (table 3). With the maximum direction of grain for fattening livestock and poultry (70%), China will be able to feed 0.983 billion people according to the recommendation of the Ministry of Health of the Russian Federation [2] (Table 3, option 7). We consider option 5 to be the best option, in which China feeds 1.6 billion people for grain and the meat norm is 39.9 kg/person per year. Therefore, China must import oilseeds to increase the meat rate to the recommended 73 kg/person per year, until the yield of oilseeds grows to 2.7 tons per ha.

Table 3. Scenarios for the forecast model of agriculture in China.

| Option | Grain feed cons. share | Cereals food consump. | Meat food consump. | Grains norm | Meat norm | Population |
|--------|------------------------|-----------------------|-------------------|-------------|-----------|------------|
|        | coefficient           | million tons          | million tons      | kg / person per year | kg/person per year | millions   |
| 1      | 0,40                   | 282,8                 | 48,3              | 100         | 17,1      | 2 827,6    |
| 2      | 0,45                   | 252,0                 | 52,2              | 100         | 20,7      | 2 520,3    |
| 3      | 0,50                   | 221,3                 | 56,0              | 100         | 25,3      | 2 212,9    |
| 4      | 0,55                   | 190,6                 | 59,9              | 100         | 31,4      | 1 905,6    |
| 5      | 0,60                   | 159,8                 | 63,7              | 100         | 39,9      | 1 598,2    |
| 6      | 0,65                   | 129,1                 | 67,5              | 100         | 52,3      | 1 290,9    |
| 7      | 0,70                   | 98,4                  | 71,4              | 100         | 72,6      | 983,5      |

Based on the calculated model to strengthen the country's food security, China can consider the following recommendations:
1. An increase in sown area is required;
2. Strengthen the development of zoned grains and oilseeds to increase productivity, taking into account the bioclimatic potential of the country's regions;
3. Irrigated lands used for the production of vegetables can be transferred from the production of vegetables to wheat, which will increase the use of crops for growing livestock and poultry, which will increase the supply of meat for food consumption.
4. Cooperation with Russia in the development of the agricultural complex can provide the necessary areas for growing oilseeds.

Conclusion

The estimated population of China, determined by models of evaluation potential of agriculture is 16000 millions of people.

The projected increase in the yield of grain and oilseeds will require additional production and the introduction of nitrogen fertilizers in the amount of 1.5 million tons, phosphorus fertilizers - 3 million tons per year, potassium fertilizers 3.2 million tons per year. Further research is needed to find out how to measure the contribution of developing China's agriculture to the national economy, and define the strategic factors that can help developing countries explore the potential of agriculture and promote economic growth.
References

[1] Klyukin N. Yu., Gutnikov V.A. Evaluation of the biological capacity of the agricultural sphere in order to determine the maximum population of the earth//Public Administration. Electronic bulletin. 2018, 69 482-497. (in Russian)

[2] Ministry of Health of the Russian Federation. Order of the Ministry of Health of the Russian Federation of August 19, 2016 No. 614 "On approval of Recommendations on rational norms of food consumption that meet modern requirements of healthy eating." (in Russian)

[3] Klyukin N.Yu.; Gutnikov V.A. Efficiency of using agricultural resources in Russia and in the world//Public Administration. Electronic bulletin. 2019, 75 482-497. (in Russian)

[4] Information on http://www.fao.org/faostat/en/#data

[5] Information on https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery

[6] Verhulst, P.F., Mathematical Researches on the Law of Population Growth, Memoirs of the Royal Academy of Sciences and Belles-Lettres of Brussels, XVIII, 184. 1-22

[7] Volterra V. The mathematical theory of the struggle for existence. Advances in Physical Sciences, 1928, Volume VIII, Iss. 01 13-34.

[8] Egorov A., Callistratov Yu.H., Mitrofanov B.A., Piontkovsky A. Mathematical models of global development. L.: Hydrometeoizdat; 1980. (in Russian)

[9] Kapitsa S.P. How many people lived, lives and will live on earth. Essay on the theory of human growth. Moscow, 1999. (in Russian)

[10] Kapitsa S.P. Phenomenological theory of population growth of the Earth, "Advances in Physical Sciences", 1996, 166 (1) 63-80. (in Russian)

[11] Kondratiev K.Ya. Global ecodynamics and its trends. In: Ecodynamics and Environmental Monitoring of the St. Petersburg Region in the Context of Global Changes. SPb. 1996. (in Russian)

[12] Chechulin V.L., Smyslov V.I., Samatkin D.Yu. An approximate model for calculating the marginal population for the countries of the world. In: article in magazine "University research" 2009-2014 Chechulin VL Perm State National Research University. Perm, 2015. pp. 548-560. (in Russian)

[13] Shorkin A.D., Model of the dynamics of the world population. Geopolitics and ecogeodynamics of regions. 2015. Vol. 1. No. 3 (11). S. 5-22.

[14] Marxist-Leninist theory of population. Ed. Valenteya D.I. 2nd edition, revised. M., “Thought” 1974 - 415 p. (in Russian)

[15] Valentei D.I., USSR—a demographic diagnosis.—M.: Progress, 1990, 696 p. (in Russian).

[16] Haub, C., How Many People Have Ever Lived on Earth? Population Reference Bureau. Retrieved March 9, 2018. Information on https://www.prb.org/howmanypeoplehaveeverlivedonearth/

[17] Vishnevsky A.G. World population explosion and its problems. Knowledge, Moscow, 1978. (in Russian)

[18] Forrester, J. World Dynamics. F79 World dynamics: Per. from English/D. Forrester. - M: LLC Publishing House ACT; TerraFantistica, St. Petersburg. 2003. (in Russian)

[19] Mesarovic M., Pestel E. Mankind at the Turning Point. Second Report to the Club of Rome. NY 1974. pp. 32-56.
[20] Gailey N., Lutz W. Demographic and Human Capital Scenarios for the 21st Century: 2018 assessment for 201 countries: Executive Summary. Luxembourg: Publications Office of the European Union. 2018.

[21] Mazoyer M.L., Roudart L. A history of world agriculture. From the Neolithic Age to the Current Crisis. Earthscan London, Sterling, VA. 2006.

[22] Meadows D.H., Jorgen Randers, Dennis L. Meadows. The Limits to Growth: The 30-year Update. Earthscan. 2006.