Some results of evaluating the level of sustainable development of agricultural production in Mongolia

Solongo Kh1., Guo Xiao Chuan1, Batkhishig I.2*

1-School of Economy and Management, University of Inner Mongolia, Hohhot, Inner Mongolia, China
2-School of Agroecology and Business, Mongolian University of Life Sciences, Darkhan, Mongolia

*Corresponding author: batkhishig@sab.edu.mn

ABSTRACT

In this research work, we evaluated the level of the sustainable agricultural development of Mongolia by a criteria consisting of 3 sub-systems and 14 indicators with a multi-index comprehensive evaluation method by using the data of 2005-2017. According to the research, the sustainable agricultural development level has reached 55.53%, where the economic sub-system has the highest impact and the social sub-system has the lowest impact but the development tendency of the environmental sub-system is at the same level as the general level and the level of sustainable agricultural development strongly depends on the environmental and climatic conditions.

KEYWORD: Economy, society, environment, evaluation, multi-indicator general evaluation method, level of sustainable development

INTRODUCTION

Sustainable agricultural development is a form of agricultural development, which is oriented on supplying the current and future generation with enough and accessible agricultural products through conservation the natural resources and introducing effective agricultural production technology, and which rationally uses and protects the land, water, animal and plant resources, does not deteriorate the environment, technologically effective, economically beneficial and commonly accepted in the society [1]. Recently, the agricultural production of Mongolia has been making progresses, however, the size of planted field has increased by 48.3% and 72.0% of total agricultural field has been over cropped [2] for the last 20 years as well domestic demand of some agricultural products depends on imports (as of 2017, 52% of the demand calculated by total agricultural products was supplied by domestic production) due to such factors as climate changes, irrational crop cultivation technology, soil fertility degradation and many others, which shows that we are at risk of leaving no agricultural production resources to the next generation as well risk of inability to supply the demands of current population. Therefore, by evaluating the level of current agricultural sustainable development and by determining the actual problems we can identify how to provide the sustainable agricultural development.

METHODS

Many countries of the world are using the multi-index comprehensive evaluation method, data envelope analysis, outcomes of agricultural scientific technology and comparative methods in evaluating the agricultural sustainable development. Among these methods, the multi-index comprehensive evaluation method has several advantages as relatively standardized calculation process, accurate
results, easy application and systematized, therefore, we have chosen this method for evaluating the sustainable agricultural development of Mongolia. In the framework of economic, environmental and social sub-systems – the three main components of the sustainable development – we selected 6 economic sub-system indicators such as unit weight of agricultural products to the GDP, total investment to the agricultural sector and labor productivity of agricultural sector; 4 social sub-system indicators such as unit weight of the workers engaged in the agricultural sector and level of labor earnings; and 7 environmental sub-system indicators such as cultivation field per capita, coefficient of irrigated field and fertilizers applied per ha. Properly selecting the criteria of sustainable development, which can represent every sub-system, is very important to the evaluation results, therefore, we selected the above 14 indicators after using and comparing the sustainable agricultural development indicators proposed by A.Bakei, L.Nyambat, B.Purev and G.Gantulga [2] and “Analysis and evaluation on assessment index system of agriculture sustainable development” by Meng Su Ying [3].

Research methods and model

The mathematical expression of the Multi-index comprehensive evaluation model method:

\[
AT_i = \sum_{i=1}^{n} W_i B_i \quad i = 1, 2, \ldots, n \quad (1)
\]

\[
B_i = \sum_{j=1}^{m} W_{ij} C_{ij} \quad j = 1, 2, \ldots, \quad (2)
\]

\(AT_i\) – Comprehensive index of sustainable development of Mongolia’s plant production sector

\(W_i\) – Weight of guidelines layer

\(B_i\) – Comprehensive index of guidelines layer

\(n\) – Number of guidelines layer

\(C_{ij}\) – Normalized value

\(W_{ij}\) – Weight of index layer index

\(m\) – Number of index layer

There is difference in sustainable development measurement unit and size, so we should normalize transfer them into same measure. To do this, we use extremum standardization and normalize the indicators.

RESULTS

Sustainable development level was calculated by using the dynamics of the sub-system indicators for the years of 2005-2017 (Table 1).

| Guidelines layer | Index layer | Computing method |
|------------------|-------------|------------------|
| Index | Weight | Index | Weight | GDP/total population |
| \(X_i\) | \(W_i\) | \(X_{ij}\) | \(W_{ij}\) | GDP/total population |
| **Econ** | 0.3751 | Unit weight of agricultural products to GDP, Agricultural products per capita, MNT (as of 2010) | 0.1509 | GDP/total production |
| | 0.1625 | Total agricultural production/Total population | 0.1625 | |

Negative index:

\[
Z_{ij} = \frac{x_{ij} - \min (x_j)}{\max (x_j) - \min (x_j)} \quad (3)
\]

Positive index:

\[
Z_{ij} = \frac{\min (x_j) - x_{ij}}{\max (x_j) - \min (x_j)} \quad (4)
\]

To account the weight of index for the standard values use standard deviation coefficient.

\[
V_j = \delta_j \frac{\bar{Z}_j}{\bar{Z}} \quad (j = 1, 2, \ldots, m) \quad (5)
\]

\[
W_j = \frac{V_j}{\sum_{j=1}^{m} V_j} \quad (j = 1, 2, \ldots, m) \quad (6)
\]

\(V_j\) – Standard deviation coefficient

\(\delta_j\) - The standard deviation of each parameter

\(\bar{Z}_j\) - Average of standard values of each indicator

\(W_j\) - The weight coefficient of each index
By amount of total investment to agricultural sector
Value added cost of agricultural sector/agricultural workers
Wheat harvest yield per ha

Domestic demand of agricultural products/amount of domestic production
Workers in agricultural sector/total employed
Average monthly wage

Population in reported period/population in baseline year

Total cultivation field/total population
Forest fund/total territory
Irrigated field/total cultivated field

Field unable for further cultivation

Note: Total investment to agricultural sector, labor productivity of agricultural sector and Labor earnings were represented by agricultural indicators and level of fertilizers per ha was represented by nitrogen fertilizer. Level of agricultural sustainable development of Mongolia gradually increased between 2008-2012 and in 2012, it reached the highest level of 55.53%. It is the result of the “Virgin Land Campaign” by the Government of Mongolia since 2008 and the average growth speed of sustainable development was 21.26% during these years (Table 2).

Table 2

| Year | Economic development coefficient | Social development coefficient | Environmental development coefficient | General level coefficient of sustainable development of agricultural sector |
|------|---------------------------------|------------------------------|--------------------------------------|---------------------------------|
| 2005 | 0.3045                          | 0.5660                       | 0.3126                               | 0.3763                          |
| 2006 | 0.3790                          | 0.3540                       | 0.2318                               | 0.3192                          |
| 2007 | 0.1980                          | 0.4360                       | 0.1653                               | 0.2489                          |
| 2008 | 0.4067                          | 0.5075                       | 0.4448                               | 0.4470                          |
| 2009 | 0.4248                          | 0.4170                       | 0.2731                               | 0.3679                          |
| 2010 | 0.4722                          | 0.4180                       | 0.3125                               | 0.4002                          |
| 2011 | 0.5948                          | 0.3676                       | 0.3990                               | 0.4642                          |
| 2012 | 0.6953                          | 0.3617                       | 0.5511                               | 0.5553                          |
| 2013 | 0.6082                          | 0.2213                       | 0.5795                               | 0.4960                          |
| 2014 | 0.7566                          | 0.3259                       | 0.4108                               | 0.5182                          |
| 2015 | 0.4875                          | 0.2971                       | 0.4335                               | 0.4178                          |
The sustainable development level was much fluctuating between 2013-2017, which strongly depended on the crop plantation, weather and climate conditions like dryness and drought and other factors in 2013 and 2015, much amount of harvest was lost during these periods, which led to sharp decrease of total production during these years and total agricultural production decreased by 11% in 2013 and by 28.8% in 2015 compared to the previous year, which led to decrease of the sustainable development coefficient. In other words, agricultural sustainable development strongly depends on the climatic conditions. It can be seen from the fact that the general coefficient of the agricultural sustainable development and the dynamics of the environmental sub-system coefficient are same in other years except 2013-2015. (Figure 1)

| Year | Economic Development | Social Development | Environmental Development |
|------|----------------------|--------------------|--------------------------|
| 2016 | 0.7315               | 0.3490             | 0.4977                   |
| 2017 | 0.4765               | 0.3357             | 0.5011                   |

![Figure 1. General level coefficient of sustainable development of agricultural sector](image)

The agricultural sustainable development sub-systems in Figure 1 show that the agricultural economic development level is higher than the general sustainable development level since 2009, which shows strong impact to the agricultural sustainable development. In particular, in 2009 it was higher than the general level by 5.68% and in 2014 the highest or 23.84%. But, labor productivity of agricultural sector, total investment and growth of the agricultural products per capita led to the economic sub-system development. It is the result of the Government efforts in renovating and modernizing the agricultural machineries of the agricultural entities through investments. Social sub-system coefficient of the sustainable agricultural development is the lowest, which shows that the agricultural social development level is weak as well it must be addressed much stronger. In particular, number of workforce in this sector is low (up to 10% of total workers are engaged in this sector) as well it shows that the agricultural production must be intensified and increased in order to supply the additional demands caused by lack of professional workforce, average life expectancy of the population and population growth.

Environmental sub-system development level has been increasing continuously since 2010 and in 2013 it reached 57.95%, although it has been gradually increasing in the following years, it hasn’t reached the above level yet. Amount of irrigated field has been increasing slowly and has reached about 10% of total agricultural field, amount of eroded and damaged agricultural field has been decreasing continuously and in 2017 it reached 70.9 thousand hectares, which had a strong impact to the development of the environmental sub-system.
DISCUSSION

According to the “Agricultural sustainable development state of Mongolia, scientific backgrounds” by A.Bakei et.al shows that the agricultural system dynamics is same as the environmental sub-system dynamics, which considers that the agricultural sector much depends on the weather and climate conditions. Arable farming or soil tillage is an important indicator of the agricultural sector, therefore, this principle was also observed in our research. The level economic sub-system development was higher than the general level, which also proves this principle. Although agriculture strongly depends on the environmental and climatic conditions, mitigating this impact is the precondition for the agricultural sustainable development.

CONCLUSION

1. The agricultural sustainable development level of Mongolia was evaluated by 3 sub-systems of economic, social and environmental and 14 indicators by using the multi-indicator general evaluation method.
2. Economic sub-system has the highest impact to the agricultural sustainable development and the social sub-system has the lowest impact. Further, it is necessary to pay more attention to the social development indicators in agricultural sector.
3. Environmental sub-system development tendency of the agricultural sustainable development is same as the general development tendency.
4. The level of the Agricultural sustainable development of Mongolia gradually increased during the “Virgin land campaign-3” or between 2008-2012 and reached 55.53% but the level fluctuated between 40-55% for last 5 years. During the years with unfavorable climatic conditions the level decreased on average by 7.5%, which proves that the level of the agricultural sustainable development still depends on the climatic conditions.

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