Comprehensive assessment of farmland resource for countries along the Belt and Road—-Based on Entropy Weight Method

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Abstract. Farmland resource performance evaluation results are important for enterprises to make overseas farmland investment decisions. Based on Entropy Weight Method, this paper has made analysis and appraisal of farmland resource performance of the countries along the Belt and Road in 2015. First we establish the farmland resource evaluation indicator system with quantitative indicator and sustainable development indicator, and a total of 8 sub-indicators. Second, we use Entropy Weight Method to calculate the weight of each sub-indicator. Third, we order the weighted scores which have been evaluated of countries along the Belt and Road. According to our analysis, the top 5 countries with high farmland resources are: Russian Federation, Lao People's Democratic Republic, Sierra Leone, Brunei and Myanmar. We hope our research can provide scientific reference for China overseas farmland investment decision-making along the Belt and Road.

1. Introduction
Farmland is an important natural resource to the people's livelihood. As the biggest developing country and the country with very scarce per capita farmland resources, China is definitely facing the food security issue. Under the background of global economic integration, overseas farmland investment is not only conducive to the spread of agricultural production technology, but also conducive to the increase of global grain output, and thus to improve the degree of food security of the whole world.

Over the last decade, overseas farmland investment has become a major part of China's foreign agricultural investment. By the end of 2015, China's overseas farmland investment stock reached $7.7×10^9, accounting for 58.6% of China's foreign agricultural investment stock[1]. In 2015, the target countries of farmland investment locate in 40 countries around the world, 35% are in the Belt and Road[2]. The Natural resources are rich along the Belt and Road, however, arable land resource and water resources are unevenly distributed in this area. Therefore, systematic analysis on farmland resource intensity of countries along the Belt and Road is a scientific fundamental of sustainable development for the overseas farmland investment.

At present, the study of overseas farmland resources is a relatively new direction. Some scholars point out rich natural resources are an important motivation for China’s investment, the higher the intensity of natural resources in the host countries, such as mineral, oil and gas et al., the more China’s
investment will flow into (Wang, 2016)\(^3\). In this paper, we formulate an Entropy Weight Method to evaluate the performance of farmland resources intensity in the host country in order to provide scientific reference for China overseas farmland investment decision making.

2. The farmland recourse intensity indicators: inputs

Resource intensity is used to measure the richness of certain types of resources in a certain area. It is usually expressed as the ratio between the resources invested and the products or services offered. The location distribution of overseas cultivated land investment is largely determined by the geographical distribution of farmland resources in the host country, of which, the intensity of farmland resources is a vital feature in the region. For different scholars, the definition of farmland resource intensity is often different. Hao (2016)\(^4\) express the farmland resource intensity by the ratio of the cultivated area to the total land area. However, Wan & Lu (2018)\(^5\) use the ratio of the permanent farmland to the area of agricultural land on behalf of the farmland resource intensity. Distinguished with traditional studies, both quantitative indicators and sustainable development indicators of farmland recourse are analysed simultaneously in this paper.

2.1. Research scope

The "One Belt And One Road" is an open international area with no precise local scope. Considering the actual situation as well as the availability of data in countries along the Belt and Road, the research scope of this paper includes 5 countries in Central Asia, Mongolia and Russia, 11 countries in Southeast Asia, 18 countries in Central and Eastern Europe, 7 countries in South Asia and 4 countries in Africa (Table 1).

| Section                        | Main countries                                                                 |
|--------------------------------|--------------------------------------------------------------------------------|
| Central Asia                   | Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan                 |
| southeast Asian countries      | Viet Nam, Laos, Cambodia, Thailand, Malaysia, Singapore, Indonesia, Brunei, Philippines, Myanmar, Timor-Leste |
| South Asia                     | India, Pakistan, Bangladesh, Afghanistan, Nepal, Sri Lanka, Maldives            |
| Central and Eastern Europe     | Poland, Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Romania, Bulgaria, Serbia, Montenegro, Macedonia, Bosnia and Herzegovina, Albania, Estonia, Lithuania, Latvia, Ukraine, Moldova, Belarus |
| South West Asia, countries in the Middle East | Turkey, Iran, Iraq, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Kuwait, Lebanon, Oman, Yemen, Jordan, Israel, Palestine, Armenia, Georgia, Azerbaijan, Egypt |
| Africa                         | Zambia, Zimbabwe, Sierra Leone, United Republic of Tanzania                    |

2.2. Farmland resource performance evaluation index system

In order to ensure that the indicator system can reflect the situation of farmland resource comprehensively and objectively, the procedure of building evaluation indicator system must comply with the quantitative indicator and sustainable development indicator. Therefore we select 8 sub-indicators from the FAO (Food and Agriculture Organization) in year 2015 to establish the farmland resource performance evaluation index system. Table 2 shows all the indicators and sub-indicators selected from the FAO, including 2 indicators and 8 sub-indicators.
Table 2. Symbols and Specification of each sub-indicator

| Indicator                     | Sub-indicator          | Specification of each sub-indicator                                                                 |
|-------------------------------|------------------------|------------------------------------------------------------------------------------------------------|
| Quantitative indicators       | Permanent crops ratio  | The ratio of the permanent farmland to the area of agricultural land. x1                             |
|                               | Arable land (hectares per person) | The ratio of the total amount of arable land to the national population. x2                     |
|                               | Arable land ratio      | The ratio of the total amount of cultivated land to the total area of a country. x3                |
| Sustainable development indicator | Expandable farmland ratio | The difference between the proportion of agricultural land and the proportion of arable land. x4 |
|                               | Irrigable farmland     | The ratio of irrigable agricultural land to total agricultural land. x5                           |
|                               | High quality farmland ratio | The ratio of organic matter cultivated area to cultivated area. x6                      |
|                               | Fresh water (per capita) | Fresh water resources average amount per capita x7                                                  |
|                               | Crop productivity index | Crop productivity index is the ratio of actual productivity of major crops to production potential x8 |

2.3. Introduction of research methods and models

Entropy method: Entropy is the concept of thermodynamics, which can determine the index weight by evaluating the index value under the objective conditions. It has the characteristics of strong objectivity, which can reflect the hidden information of the data and enhance the significance and difference of the index. The idea is that the greater the difference in the value of an index, the greater the weight of index\(^6\). According to the degree of variation of each index, the weight of each index can be calculated objectively, which provides the basis for the comprehensive evaluation of multiple indexes. The calculation steps are:

Set the original evaluation index matrix of regional farmland resources as:

\[
V = \begin{bmatrix}
  v_{11} & v_{12} & \cdots & v_{1n} \\
  v_{21} & v_{22} & \cdots & v_{2n} \\
  \vdots & \vdots & \ddots & \vdots \\
  v_{m1} & v_{m2} & \cdots & v_{mn}
\end{bmatrix}
\]

(1)

Where V is the initial evaluation matrix, \(v_m\) represents each country, \(v_n\) is the sub-indicator.

To get a standardized evaluation matrix, we use a normalized method to process the original evaluation index. For the benefit (the larger the better) indicator, see formula (2), for the cost (the smaller the better) indicator, see formula (3). Then we get the normalized matrix, see formula (4).

\[
r_i = \frac{v_i - \min(v_i)}{\max(v_i) - \min(v_i)}
\]

(2)
\[ r_i = \frac{\max(v_i) - v_i}{\max(v_i) - \min(v_i)} \]  
\[ R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \]  
(4)

Where \( r_i \) represents the normalized value of country \( i \).

The information entropy for each index is defined as:
\[ w = \frac{1 - H_i}{m - \sum_{i=1}^{m} H_i} \]  
(5)

In formula (5), information entropy is \( H_i = -\frac{1}{\ln n} \sum f_i \ln f_i \), and the characteristic weight of the index is \( f = \frac{r_i}{\sum r_i} \).

3. The outputs and results discussions:

According to the calculation, the Entropy Weight Method based weight of each farmland recourse sub-indicator is presented in Table 3.

|    | W1  | W2  | W3  | W4  | W5  | W6  | W7  | W8  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|
|    | 0.156| 0.066| 0.082| 0.109| 0.142| 0.256| 0.159| 0.031|

From above Table 3 we find that: crop productivity index (W8) has the lowest weight, which proves that crop productivity is relatively balanced among countries. However, high quality farmland ratio (W6) has the max weight value, followed by fresh water (per capita), permanent crops ratio and irrigable farmland ratio, which means these indicators keep changing over time, and water resource is an important factor for the farmland resource performance.

4. Conclusions and further study works

In this paper, we combine the quantitative indicator and sustainable development indicator to establish the farmland resource performance system, and we use Entropy Weight Method provide an objective and comprehensive evaluation of the farmland resource. Furthermore, we order the weighted scores which have been evaluated of various countries. The top 5 countries with high farmland resources are: Russian Federation, Lao People's Democratic, Republic Sierra Leone, Brunei and Myanmar.

The investigation of the types, quantity and sustainable development of farmland resource for countries along the Belt and Road is the basic precondition for farmland investment. Meanwhile there are considerations in the investment process that the host country selection regarding China’s overseas farmland investment is different from the general sense of foreign direct investment, we also recommend that in the further study, the implications of country risk and trade distance need to be considered when making investment decisions.

Finally, counterpart policies should be made according to the unique characteristics to ensure the rationally implementation of China’s overseas farmland investment.
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