Index system of rural human settlement in rural revitalization under the perspective of China

Qi Liu1,2*, Decai Gong1 & Yuxuan Gong3

Rural revitalization strategies are an important task in China. Currently, it is in the transition from poverty alleviation to rural revitalization. This paper proposes an evaluation index of rural revitalization and development potential based on a summary of previous studies. Together with the TOPSIS method, the corresponding coefficients of each index layer and the weight coefficient of the criterion layer were analyzed. This shows that during the process, the work direction of rural revitalization varies based on different revitalization types. In this study, diagnostic tools are utilized to conduct a potential development analysis of rural human settlements by identifying the main influencing factors for rural revitalization. In addition, an index system for improving rural human settlement strategies is established. Overall, it helps in defining the interventions of reducing and managing the risk of rural vitalization and evaluating the potential ability of rural revitalization. It also suggests that Anhui Province should focus on carrying out the comprehensive revitalization of rural areas according to the different functional positions of the countryside.

Rural area is a complex system composed of social, economic and environmental factors. It is the spatial carrier of working and living1. Rural revitalization is rooted in rural development2. In international experience and scientific studies3,4, Rural development (RD) is a tactic that invented to improve the economic and social life of rural areas. The concept of human settlement is the result of interaction between urban and rural human settlements. Greek scholars5 first proposed human settlements as a whole. However, there is a huge difference between urban human settlement and rural human settlement6. Population is a main factor of production in China’s rural development, this is an important foundation to understand the situations in rural China and the implementation of rural revitalization7.

China’s urbanization rate rose from 17.92% in 1978 to 60.60% in 2019 (National Bureau of Statistics PRC, 2020). The imbalance between urban and rural regions, as reflected for example in the level of education, the current level of higher education is less than 40% in rural area8; In European experience and scientific reviews, A Rural Development Policy (EU) aims to assist rural areas cope with range of environmental, economic and social challenges9. Meanwhile, Marsden et al.10 explore some conceptual parameters required for the rural development dynamic. Adamowicz present the way of defining rural areas: tactic and development planning in Europe11. Some people believe that rural development analysis is a research theme developed in Europe based on scientific reasons and contributions to policy decision-making12. Biegańska et al.13 focus on changing of demographic and social aspects caused by development around the city in rural areas in Latvia, Poland, and Germany, a number of rural regions face persistent population decline. In Korea experience14–16, It discussed rural development policies currently upgraded by the South Korean in terms of questions such as the decrease of agricultural productivity, the depopulation in rural areas. Faradiba et al.17 aim to look for the impact of climate, disaster, and social community on rural development. In India experience, Effective policy making for the Rural Development (RD) is the need of hour. RD included reconstruct of life aspects of human that consists of social, political and economic of human beings.

Based on review of rural development index literature, the research on rural index has been covered all over the world. Kaneko et al.18 conduct a systematic scoping review to determine the important factors and methodological to be considered in the rural index and provide suggestions for the development of rural index in Japan. Other influential work includes Yokoyama et al.19; Abreu et al.3 propose the designed rural development index(RDI) that will cover the defining characteristics of regional development. LOBÃO et al.12, aim to analyse the extent to which the development level and dynamics of rural regions located in two different countries,
Austria and Portugal. Hennebry et al.20 analyze the rural development level of Brazilian Amazon municipalities in the decade 2000–2010 based on RDI calculated for more than 400 municipalities. The main objective of Michalek et al.21 was to build a comprehensive index to scale the level of rural development and quality of life in rural residents of a specific EU country. The contribution of Liu et al.22 is to evaluate the current situation of county level rural areas in the eastern coastal China. The purpose of Kim et al. 23 is to analyze the current situation and process of rural development in Vietnam and draw lessons for realizing rural sustainable development. However, all the previously mentioned studies suffer from some serious. Firstly, One criticism of many literature on RDI is theoretical progress, existing studies have identified the concept of RDI, but didn't figure out the internal composition of RDI and practice of classification at the macro level, specially refer to the human rural settlement. Secondly, in research scale point of view, researchers mainly focus on village scales instead of the national regional level. In the end, The research to date has tended to focus on the different functions of rural development are always seen as relatively independent elements rather than analyzing from an comprehensive and combined perspective. Thus, rural human settlement needs an index system to illustrate the relationship between important elements inside rural revitalization.

This framework was created to provide guidance in the assessment of the potential development ability of rural revitalization. Currently, it is in the transition from poverty alleviation to rural revitalization in China. To smoothly pass through the transition period, a fraction of policies came into existence by the Chinese government, such as the three-year action plan for rural human settlements and the five-year action of rural human settlement improvement, especially rural revitalization strategies24. Scholarly and policy work confirms the importance of rural development, and these policies and methods have pointed out the direction for rural development to a certain extent25.

In addition, China's No. 1 central document specifically highlights the significance of solving the relationship and problems among three factors, i.e., agriculture, countryside and farmers. The construction of rural revitalization is an important source of farmers' happiness and sense of achievement Zhang et al.26 to completely construct an affluent society. The review of academic sources on the evaluation of rural revitalization is mainly concentrated on the macroscopic level27. However, few academic studies have clarified the characteristics of rural human settlements in the microscopic stratification plane. A comprehensive understanding of rural human settlements is considered the foundation and premise condition for the transition from poverty alleviation to rural revitalization in China28. The comparison of rural human settlements should include not only multiple regions but also summarize the differences between different regions. It will better reveal the importance of human beings in the process of rural revitalization.

Research aim
The research objective of this paper is to evaluate the relationship between rural revitalization, i.e., industrial prosperity, ecological livability, rural civilization, effective prosperity, and quality of life in Anhui Province of China (Fig. 1). As the birthplace of China's rural reform and a major agricultural province, in order to better understand the effect of poverty alleviation in Anhui Province and achieve rural revitalization in future research steps. The proposed establishment of an index system is beneficial to evaluate the level of risk of rural revitalization. In addition, it allows us to analyze the potential ability of rural development. From this perspective, this approach is applicable to support scholars and experts in the area of rural revitalization and in the comparison of managing the different levels of development in Anhui Province.

Figure 1. (a) The geographical location of China. Source: Obtained from http://o.southgis.com/news/detail/6028; (b) The geographical location of Anhui Province. Source: Obtained from http://zrzyt.ah.gov.cn/ztlm/ahszbdtfw/index.html.
Theory and background

The major purpose of this study is to estimate the property of human rural settlement. Alongside the historical enhancement of science, there are plenty of indicators to measure development (Gross Domestic Product (GDP); Environmental Sustainability Index (ESI) and Human Development Index (HDI) et al.).

Together with other national development indices (e.g. the EU rural development index, the SRDI, LHDI-low human development index et al.), A number of studies show that the evaluation of development index always combined with theory of sustainability, i.e. the Ecosystem Health Index (EHI) was built up according to the Sustainable Development Goals (SDGs) [31]; Sustainable Rural Development Index (SRDI) is developed on the basis of Rural development index (RDI); Human development index (HDI) is an index that measures key points of human development: healthy of life; education; quality of living. RDI from Kageyama and RHDI from Abreu et al. also applied in regional development discussion in Italy [34] and SRDI in village of Hajij, Iran [35]. Banakar et al. studied that the index was developed can be used to compare with the development level in rural places. Many researchers presented the extent of development in rural areas from different dimensions, i.e. The conceptual Index that proposed with five domains as given below: Economy; Education; Health; Environment; Culture and Leisure, the research comprehensively evaluates the development level of rural comprehensive based on theory of rural regional system from four dimensions: environmental system, resource system, humanistic system and economic system.

Meanwhile, many scholars are also engaged in related research (e.g. the works of Ravallion, Sabina Alkire, James Foster, Kageyama, Abreu et al.). Alkire et al. present a new Multidimensional Poverty Index (MPI), which can be used as a method of measuring poverty. Meanwhile, They explained the preponderance, localization, and misreading of multidimensional poverty measurement. Moreover, they examined how rule-based reasoning was used to actual proof application of various indicator in order to make MPI to accord with the SDGs [36–39]. Compared with all those indices, there are also two concrete indicator had established to evaluate RD [32, 33]. The indicators that are divided into four parts, but the indicators do have the limitations that endorsed by the literature.

The studies reveal that there are various indices proposed in view of the rural development the research takes into account the literature proposed in developing this conceptual research. Firstly, the indices of RD that are grouped into different dimensions and the indices of SRD Which is from sustainable development point of view, this is a dynamic process instead of a static perspective [40]. Moreover, the main point is to evaluate development process under given index, but it may or may not going in a sustainable way. Secondly, the indices pay almost exclusively attention on national ranking and representation, but does not focus on further development from a specific point of view. In conclusion, This paper not only take dynamic process into consideration (Currently, it is in the transition from poverty alleviation to rural revitalization in China.), but also including the static single indicators measurement to explain how the effect of the first stage of poverty alleviation at present. Thus, both indices (RDI and HDI) together with perspective of China have been considered in the rural human settlement index. There still needs an discussion on how to measure the rural development in a better way, specially in the transition from poverty alleviation to rural revitalization due to special.

According to the twenty-character policy of rural revitalization, the majority of scholars carried out the evaluation of new rural construction [41] from different perspectives, such as new farmers, developed agriculture and harmonious rural areas. For the evaluation index of beautiful rural construction, the majority of scholars set up the index system from five aspects: ecological economy, ecological environment, ecological human settlement, ecological culture and ecological support guarantee, which laid a good foundation for the evaluation of rural revitalization.

In this paper, we selected industrial prosperity, effective governance, ecological livability, rural civilization, and quality of life. These five factors were taken as the main research area in the index system to establish an index system of rural revitalization in human settlement. As a result, efforts have been made to transition from poverty alleviation to rural revitalization in China.
The selected evaluation index of rural development level should reflect the development level of villages and towns as comprehensively as possible. According to the principles of scientificity, simplicity, relative independence, objectivity and data availability of index selection, combined with the above research results in China and abroad. Based on the above connotation of "Rural Revitalization", this paper proposes an evaluation index system of "Rural Revitalization" in Anhui Province. According to the design principles of the index system, the five aspects of politics were taken into consideration, i.e., industrial prosperity, ecological livability, rural civilization, effective prosperity, and quality of life. In the specific index system setting, it will be divided into three target levels: the first level is rural revitalization; the second level includes industrial prosperity, ecological livability, rural civilization, effective prosperity, and quality of life; and the third level is composed of several single aspects, i.e., economic, environmental, and social welfare aspects.

Based on the current situation, it is in the transition from poverty alleviation to rural revitalization in China. The studies reveal that there are various indices proposed in view of the rural development research takes into account the literature proposed in developing this conceptual research. But also take both indices (RDI and HDI) together with perspective of China into consideration in sample selection. Thus, sample selection include three parts: According to twenty-character policy of rural revitalization, that is, industrial prosperity, ecological livability, rural civilization, and quality of life in China, Academic literature on the topic, Literature review of index selection in China perspective.

Table 1. Index establishment of Rural Revitalization.

| Target layer | Criteria layer | Indicator layer |
|--------------|---------------|----------------|
| Rural revitalization | Industrial prosperity | Productive capability |
| | Ecologically livable | Planting area of main crops |
| | Ecologically livable | Output rate of rural labor force |
| | Rural civilization | The level of Rural health |
| | Effective governance | Rural tap water penetration rate |
| | Quality of life | Education level of farmers |
| | | Number of community service facilities |
| | | Coverage rate of cultural relics |
| | | Household biogas utilization rate in rural areas |
| | | Per capita disposable income of rural residents |
| | | Consumption level of rural residents |
| | | Rural employment rate |
| | | Penetration rate of rural electricity consumption |

Materials and method

Background of index system. The 19th National Congress of the Communist Party of China put forward the ‘twenty-character’ policy of implementing rural revitalization, that is, industrial prosperity, ecological livability, rural civilization, effective governance, and good quality of life. In view of the 20-character policy and based on the summary of previous related studies, this research puts forward the evaluation system of rural revitalization and level of development, clarifies the potential of different villages to revitalize and develop, guides the choice of rural development direction, and provides a theoretical basis for the local government to protect rural culture and promote industrial revitalization.

The measure of index establishment. Based on the current situation, it is in the transition from poverty alleviation to rural revitalization in China. The studies reveal that there are various indices proposed in view of the rural development research takes into account the literature proposed in developing this conceptual research. But also take both indices (RDI and HDI) together with perspective of China into consideration in sample selection. Thus, sample selection include three parts: According to twenty-character policy of rural revitalization: industrial prosperity, effective governance, ecological livability, rural civilization, and quality of life in China, Academic literature on the topic, Literature review of index selection in China perspective.

The selected evaluation index of rural development level should reflect the development level of villages and towns as comprehensively as possible. According to the principles of scientificity, simplicity, relative independence, objectivity and data availability of index selection, combined with the above research results in China and abroad. Based on the above connotation of "Rural Revitalization", this paper proposes an evaluation index system of "Rural Revitalization" in Anhui Province. According to the design principles of the index system, the five aspects of politics were taken into consideration, i.e., industrial prosperity, ecological livability, rural civilization, effective prosperity, and quality of life. In the specific index system setting, it will be divided into three target levels: the first level is rural revitalization; the second level includes industrial prosperity, ecological livability, rural civilization, effective prosperity, and quality of life; and the third level is composed of several single evaluation indicators under the second level, with a total of 13 indicators (Table 1) as the third level scalar layer.

The following evaluation indicator system was developed:

Data source. Anhui Province and 2019 were selected as the research unit and time. The data are constructed by spatial and attribute data separately. The spatial boundary included administrative boundaries (the 1:1000000 basic geographic information database of China). Attribute one comes from statistical data collected by the related state departments. The data included, but were not limited, infrastructure data, environmental data, and social and economic data. These data came from the China Urban Rural Construction Statistical Yearbook, China Rural Poverty Monitoring Report, China Statistical Yearbook, China Social Statistics Yearbook, China Environmental Statistics Yearbook and China Rural Statistical Yearbook.

Methods. In the selection of method stage, the studies shows that during the preliminary decision-making phases, there are various methods, i.e. SWOT; Delphi et al. i.e. On account of the SWOT analysis and the attitudes of the local population, that determine the SRD index which comprise twenty indicators. Abreu et al. propose the SRD index through a Delphi method. Which consist of 25 indicators from demographic, economic, environmental, and social welfare aspect.

However, how to select a relevant MADM which is Multiple Attribute Decision Making method for a given question has been highlighted in studies. It is necessary to do the comparison for method. Firstly, in comparison to the subjective fixed weight methods for instance the Delphi method, comprehensive index method, fuzzy comprehensive evaluation method, the analytic hierarchy process method (AHP) etc., the entropy weighting method can explain the results acquired more exact and objective. It conclude three steps: set up the assessment matrix, rescale the matrix and calculate the entropy weight.
Secondly, Yoon et al. had developed TOPSIS, its definition is Technique for Order Preference by Similarity to Ideal Solution\(^5\), and it is also an MCDM (multi-criteria decision making). TOPSIS is derived from the idea that the geometric distance of chosen one should be the shortest from the positive ideal solution and the longest from the negative ideal answer, which is the method to optimize responses\(^5\). Based on the available literature studies, specially in contrast to the single response optimization techniques\(^5\), it is clear that the benefits of the TOPSIS model is more simple, reasonable, understandable, high computing efficiency. Therefore, and in the existing methodologies, researchers can test alternatives and decision criteria through the use of numerical tool.

Thus, according to the summary of previous related studies, this paper puts forward the evaluation index of rural revitalization and development potential and analyzes the corresponding coefficients of each index layer and the weight coefficient of the criterion layer. The TOPSIS method was selected by comparison with the comprehensive index method, fuzzy comprehensive evaluation method and AHP method.

**Building decision matrix.**

\[
x = \begin{bmatrix}
x_{11}x_{12} \cdots x_{1,13} \\
x_{21}x_{22} \cdots x_{2,13} \\
\vdots \\
x_{16,1}x_{16,2} \cdots x_{16,13}
\end{bmatrix}
\]  

**Dimensionless method.** Different dimensions were observed in the evaluation index of rural revitalization of Anhui Province. For the convenience of data processing, dimensionless data were carried out first, which means that all units of the equation of a physical quantity are removed by replacement with a suitable variation to simplify the purpose of calculation. In this paper, the method of extreme difference transformation is used. In the decision matrix:

\[
x = \begin{pmatrix} x_{ij} \end{pmatrix}_{16 \times 13}
\]

Target \(j\) for \(i\) cities, then:

\[
z_{ij} = \frac{x_{ij} - \min_{i} x_{ij}}{\max_{i} x_{ij} - \min_{i} x_{ij}}, \quad j = 1, 2, 3 \ldots 13
\]

Therefore, turning to the indicator, at the same time \(0 \leq |x| \leq 1\), the matrix will be the new matrix:

\[
z = \begin{pmatrix} z_{ij} \end{pmatrix}_{16 \times 13}
\]

**Indicator wet set.** To reflect the difference between the main and secondary evaluation factors and increase the comparability, the entropy weight method is used to determine the weight of each evaluation index. The entropy weight method can determine the index weight according to the amount of information contained in the objective index. It helps to avoid the interference of index information data acquisition and has high reliability. The steps are as following. For matrix:

\[
z = \begin{pmatrix} z_{ij} \end{pmatrix}_{16 \times 13}
\]

To calculate the average value of every evaluating indicator:

\[
\bar{z}_j = \frac{1}{16} \sum_{i=1}^{16} z_{ij} (j = 1, 2, 3 \ldots 13)
\]

Then, the standard deviation of the evaluation value is calculated:

\[
t_j = \sqrt{\frac{1}{16 - 1} \sum_{i=1}^{16} (z_{ij} - \bar{z}_j)^2} (j = 1, 2, 3 \ldots 13)
\]

Calculate the coefficient of variation of the evaluation value of each index

\[
M_j = \frac{t_j}{\bar{z}_j} (j = 1, 2, 3 \ldots 13)
\]

Finally, the index weight is obtained by normalization:

\[
w_j = \frac{M_j}{\sum_{j=1}^{13} M_j} (j = 1, 2, 3 \ldots 13)
\]
First, the weighted standardized matrix is calculated from the normalized decision matrix and the index weight vector to obtain the weighted standardized moment array. Second, to determine the positive and negative theoretical solutions, positive and negative theoretical solutions can be obtained from the previous step. Third, calculate the distance from the evaluation vector to the positive and negative ideal solutions every year. The distance value from the evaluation vector to the positive and negative ideal solutions is 

\[ L^+_i \]

and 

\[ L^-_i \]:

Finally, the relative closeness of the evaluation vector every year is calculated:

\[ K^*_i = \frac{L^-_i}{L^-_i + L^+_i} (j = 1, 2, 3 \ldots 13) \]

Table 2. The weight of the evaluation index.

| Area                                | Information entropy | Information utility value | Weight coefficient |
|-------------------------------------|---------------------|---------------------------|--------------------|
| Productive capability               | 0.8905              | 0.1095                    | 7.60%              |
| Planting area of main crops         | 0.8897              | 0.1103                    | 7.65%              |
| Output rate of rural labor force    | 0.9262              | 0.0738                    | 5.12%              |
| The level of Rural health           | 0.9062              | 0.0938                    | 6.51%              |
| Rural tap water penetration rate    | 0.9328              | 0.0672                    | 4.66%              |
| Education level of farmers          | 0.8186              | 0.1814                    | 12.59%             |
| Number of community service facilities | 0.8894            | 0.1103                    | 7.67%              |
| Coverage rate of cultural relics    | 0.7901              | 0.2099                    | 14.56%             |
| Household biogas utilization rate in rural areas | 0.8738 | 0.1262               | 8.76%              |
| Per capita disposable income of rural residents | 0.8275 | 0.1725               | 11.97%             |
| Consumption level of rural residents | 0.8924           | 0.1076                    | 7.46%              |
| Rural employment rate               | 0.9565              | 0.0435                    | 3.02%              |
| Penetration rate of rural electricity consumption | 0.9650 | 0.0350               | 2.43%              |

**Comprehensive ranking of indicators.** First, the weighted standardized matrix is calculated from the normalized decision matrix and the index weight vector to obtain the weighted standardized moment array. Second, to determine the positive and negative theoretical solutions, positive and negative theoretical solutions can be obtained from the previous step. Third, calculate the distance from the evaluation vector to the positive and negative ideal solutions every year. The distance value from the evaluation vector to the positive and negative ideal solutions is 

\[ L^+_i \] and 

\[ L^-_i \]:

Finally, the relative closeness of the evaluation vector every year is calculated:

\[ K^*_i = \frac{L^-_i}{L^-_i + L^+_i} (j = 1, 2, 3 \ldots 13) \]

**Results and discussion**

**Visualization chart.** The research aim of this paper focused on evaluating the relationship between rural revitalization, i.e., industrial prosperity, ecological livability, rural civilization, effective prosperity, and quality of life in Anhui Province of China (Table 2). In Anhui province, there are 16 cities totally and Hefei is the capital city of the province. After data processing (Fig. 2), different colors represent different results in numerical order. The lighter the color is, the higher the ranking. Similar to the value of \( k^+ \), according to the comprehensive evaluation value, the larger the value is, the better the effects of rural revitalization. From a geographical point of view, the score of the northwest is higher than that of the southeast area. As shown below, to build the rural revitalization demonstration area, it should focus on areas with higher development levels in the early stage (Table 3).

**Development level of index.** To reflect Anhui Province more objectively and clearly, the criteria layers should also be evaluated separately (Fig. 3). Table 4 shows the ranking in five different criteria layers. Huangshan plays a significant role in effective governance (Fig. 4), which leads to its high comprehensive ranking. Hefei, as a provincial capital place in Anhui, has the highest level of quality life, but compared to other aspects, it needs to be improved through effective governance and rural civilization.

Furthermore, solving the problem of differentiation in rural areas, applying contemporary types and classifications, and putting personalized methods into practice will certainly contribute to the development of rural revitalization. From a multidimensional perspective, rural revitalization is a strategy to improve rural resilience, and it is also useful to promote sustainable development. Different rural areas play different roles in the end. Eco-friendly villages pay attention to solving the contradiction between ecological environment protection and traditional ecological poverty alleviation and construct the realization path of green poverty reduction; deep poverty-stricken areas eliminate poverty by developing industries with regional characteristics, implementing ecological protection and green development, relocation and other measures. On this basis, to provide financial security and enhance the endogenous development capacity of developing areas, the goal is to help farmers solve the problem of financing for development and constantly innovative financial services mechanisms.

Consequently, before rural revitalization, it is necessary to carry out an evaluation of the situation of poverty alleviation and the development potential of rural revitalization in various regions to select countermeasures and carry out the work.
Conclusion

Based on the assessment of the current poverty alleviation and the preliminary judgment of the existing data using the TOPSIS method, the following conclusions are drawn:

To achieve rural revitalization, it is necessary to consider the connection between poverty alleviation and rural revitalization. Currently, rural revitalization is the goal of rural development, poverty alleviation is the foundation and premise of rural revitalization, and rural revitalization is the consolidation and deepening of poverty alleviation in China. The relationship between poverty alleviation and rural revitalization is the integration of content, interaction and consistency of the main body. To overcome the relationship between the stage of poverty and solving long-term relative poverty should be the first step, and then it can help in solving the problem of extreme poverty. Then, it will be possible to achieve rural revitalization after overcoming poverty and the key points. Thus, China’s No. 1 central document pointed out that giving full play to the rural industry supply, ecological barriers, cultural heritage and other functions to consolidate and expand the achievements of poverty alleviation and rural revitalization effective convergence in 2021.

To achieve rural revitalization, it is necessary to give full play to the rural industry supply, ecological barriers, cultural heritage and other functions. The ecological environment is the greatest advantage and wealth in rural areas. Making full use of good ecological resources and achieving rural ecological livability is the key to effectively
linking rural revitalization. Rural cultural revitalization can promote the development of the rural cultural industry and is an open channel for local tourism, folk customs and intangible cultural heritage. Furthermore, rural cultural protection not only protects the characteristic culture but also promotes local economic development. Industrial development compacts the material foundation from poverty alleviation to revitalization, explores the development direction of rural industry and seeks industrial revitalization.

To achieve rural revitalization, it is necessary to achieve regional classification and to excavate endogenous potential, which is critical to rural regions. Rural classification is applied in many countries. Marsden1995 analyzed the development levels of agricultural systems and divided these villages into different types: production-oriented villages and integrative villages according to the period of rural development. To collect rural migration models, Bijker et al.56 evaluated the popularity degree of rural areas according to the landscape and employment and divided rural areas into popular and less popular areas. Thus, it is important to start a diagnostic system to classify various villages. Thus, the symbol to measure whether rural revitalization occurs mainly lies in whether the special and necessary functions of the areas have been fully played. Anhui Province has different rural resource endowments, various industrial types and different stages of rural historical development. In general, the differentiation of rural functions is an indisputable fact. The main direction of development at different stages should also be different.

**Figure 3.** (a) The level of ecological liveability in Anhui Province; (b) The level of rural civilization in Anhui Province.

**Table 4.** Ranking results in five aspects of Anhui province.

| Area     | Industrial prosperity | Ecologically livable | Rural civilization | Effective governance | Quality of life |
|----------|-----------------------|----------------------|--------------------|----------------------|----------------|
| Hefei    | 4                     | 6                    | 6                  | 8                    | 1              |
| Huaibei  | 16                    | 16                   | 15                 | 16                   | 16             |
| Bozhou   | 5                     | 3                    | 2                  | 10                   | 11             |
| Suzhou   | 2                     | 2                    | 3                  | 15                   | 13             |
| Bengbu   | 6                     | 14                   | 4                  | 12                   | 5              |
| Fuyang   | 1                     | 1                    | 1                  | 6                    | 4              |
| Huainan  | 8                     | 15                   | 10                 | 3                    | 8              |
| Chuzhou  | 3                     | 11                   | 7                  | 11                   | 10             |
| Luan     | 7                     | 4                    | 8                  | 9                    | 9              |
| Maanshan | 15                    | 10                   | 12                 | 14                   | 3              |
| Wuhu     | 10                    | 7                    | 11                 | 7                    | 2              |
| Xuancheng| 11                    | 8                    | 13                 | 5                    | 6              |
| Tongling | 12                    | 13                   | 14                 | 13                   | 14             |
| Chizhou  | 14                    | 12                   | 16                 | 2                    | 15             |
| Anqing   | 9                     | 5                    | 5                  | 4                    | 12             |
| Huangshan| 13                    | 9                    | 9                  | 1                    | 7              |
Currently, it is in the transition from poverty alleviation to rural revitalization in China. Achieving rural revitalization is a long-term dynamic construction process. On the basis of the achievements of poverty alleviation, evaluating the effectiveness of the work is necessary and urgent. Therefore, the next stage should focus on how to carry out the comprehensive revitalization of the rural area according to the different functional positioning of the countryside.

Received: 27 October 2021; Accepted: 23 May 2022
Published online: 22 June 2022

References

1. Parra-Lopez, C., Groot, J. C. I., Carmona-Torres, C. & Rossing, W. A. H. Integrating public demands into model-based design for multifunctional agriculture: an application to intensive Dutch dairy landscapes. *Ecol. Econ.* **67**(4), 538–551 (2008).
2. Pinto-Correia, T., Guiomar, N., Guerra, C. A. *et al.* Assessing the ability of rural (2016).
3. UPA. Desarrollo rural. Oportunidades Desaprovechadas La Tierra **254**, 31–33 (2016).
4. Abreu, I., Nunes, J. M. & Mesias, F. J. Can rural development Be measured? Design and application of a synthetic index to Portuguese municipalities. *Soc. Indic. Res.* **145**, 1107–1123 (2019).
5. Doxiadis, C. A. *Ekistics: an introduction to the science of human settlements* (Oxford University Press, 1968).
6. Algeciras, I. A. R., Coch, H. & Perez, G. D. L. P. Human thermal comfort conditions and urban planning in hot-humid climates - The case of Cuba. *Int. J. Biometeorol.* **60**, 1151–1164 (2016).
7. Zhang, H., Zhang, S. & Liu, Z. Evolution and influencing factors of China’s rural population distribution patterns since 1990. *PLoS ONE* **15**, e0233637 (2020).
8. Eurostat. Eurostat Regional Yearbook. 2019 Edition. Publications Office of the European Union, Luxembourg (2019)
9. Overview of CAP Reform 2014–2020. Agricultural Policy Perspectives. Brief, no. 5, December 2013. European Commission.
10. Marsden, T. & Sonnino, R. Rural development and the regional state: denying multifunctional agriculture in the UK. *J. Rural Stud.* **24**(4), 422–431 (2008).
11. Adamowicz, M. Normative Aspects of Rural Development Strategy and Policy in The European Union Normative Aspects of Rural Development Strategy and Policy in The European Union, (2018)
12. Léon, Y. Rural development in Europe: a research frontier for agricultural economists. *Eur. Rev. Agric. Econ.* **32**, 301–317 (2005).
13. Biegańska, J., Środa-Murawska, S., Kruzmetra, Z. & Świączny, F. Peri-Urban development as a significant rural development trend. *Quaest. Geogr.* **37**, 125–140 (2018).
14. Lee I.-H. Change of rural development policy in South Korea After Korean War. J. Reg City Plan, 2021.
15. Oh, Y.-Y. *et al.* The selection of proper resource and change of salinity in *Helianthus tuberosus* L. cultivated in Saemangeum reclaimed tidal land. *Korean J. Environ. Agric.* **37**, 73–78 (2018).
16. Yoon, J.-Y., Jeong, J.-H. & Choi, S.-K. Validation of reference genes for quantifying changes in physiological gene expression in apple tree under cold stress and virus infection. *Radiat. Prot. Dosim.* **26**, 144–138 (2020).
17. Faradiba, F. & Zet, L. The impact of climate factors, disaster, and social community in rural development. *J. Asian Finance Econ. Bus.* **7**, 707–717 (2020).
18. Kaneko, M., Ohta, R., Vingilis, E. & Mathews, M. Thomas Robert freeman; systematic scoping review of factors and measures of rurality: toward the development of a rurality index for health care research in Japan. *BMC Health Services Res.* **21**, 1–11 (2021).
19. Yokoyama, S. Sustainable activities for rural development, New Frontiers in Regional Science: Asian Perspectives, (2019).
20. Georgios, C., & Barrai, H. Social innovation in rural governance: a comparative case study across the marginalised rural EU. *J. Rural Stud.* (2021)
21. Michalek, J. & Zarnekow, N. Application of the rural development index to analysis of rural regions in Poland and Slovakia. *Soc. Indic. Res.* **105**, 1–37 (2012).
22. Liu, Y., Wang, G. & Zhang, F. Spatio-temporal dynamic patterns of rural area development in eastern coastal China. *Chin. Geogr. Sci.* **23**, 173–181 (2013).

Figure 4. (a) The level of effective governance in Anhui Province; (b) The level of quality of life in Anhui Province.
Author contributions Q.L. and D.G. wrote the main manuscript text. D.G., Q.L. and Y.G. participated in the design of this study, and they both performed the analysis. All authors reviewed the manuscript.
Competing interests
The authors declare no competing interests.

Additional information
Correspondence and requests for materials should be addressed to Q.L.
Reprints and permissions information is available at www.nature.com/reprints.
Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

© The Author(s) 2022