Research on a diagnostic system of rural vitalization based on development elements in China

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\textbf{ABSTRACT}

In 2017, the Chinese government implemented a national strategy of “Rural Vitalization” that sought to realize full-scale rural vitalization. However, is it possible to achieve vitalization for all the villages in China? How should their development potential be determined? This paper identified and analyzed the “element-composite” messages of rural development based on 99 exemplary sites of “Beautiful Villages” in China. Combined with the projection pursuit classification method, a diagnostic system of rural vitalization was established; then, Dehua County was taken as a case study for an in-depth analysis. Based on national data analysis, the final results indicated that livelihood resources (LR), agglomeration effects (AE), location and transportation (LT), cultural/natural landscapes (CN), and economic circumstance (EC) are essential elements for successful rural development. Additionally, EC was the only exogenous element, while the remaining elements were endogenous. Furthermore, the villages with better EC presented urbanization rates of 38∼82 % and Engel coefficients of 29∼41 % in their counties; exemplary sites lacking LR, CN, LT, and AE account for 13.13 %, 19.19 %, 26.26 %, and 60.61 % respectively, so the indispensability of these elements decreases progressively in sequence. Only 2 % of villages rely on single element for success, therefore, the composite pattern of development element was also critical; 10 out of 16 types were found to successfully facilitate village development, among which, the type of R-a-L-C (32.32 %) and R-A-L-C (15.15 %) were considered as the greatest potential patterns for vitalization. Finally, by means of the diagnostic system, the ratio of representative villages for high-low potential in Dehua County is evenly split; then, development paths, and land use policies that match with paths were proposed, on the basis of development potential and “element-composite” condition of themselves.

1. Introduction

As an organic system, cities and villages interacted with each other and support each other (Liu and Li, 2017). However, rapid economic liberalization has led to socio-economic polarization between cities and villages; meanwhile, the rural decline is inevitable and has become a serious global issue (Rizzo and Khan, 2013; Munya et al., 2014). Currently, approximately 45 % of the world’s population lives in rural areas (The Food and Agriculture Organization (FAO, 2018). Their lives need more considerable attention and improvement, including equal access to resources, public services, and social welfare. Fortunately, politicians and researchers in various countries have realized the prime importance of rural development and thus have focused on avoiding continued rural decline (Pierskalla, 2015; Fieldsend, 2013).

Since the “Reform and Opening up” policy, agriculture and the rural economy have made great contributions and sacrifices to the prior development of industry and the urban economy in China (Long et al., 2010), which directly led to cities and villages thriving and declining, respectively. In 2017, there were approximately 0.6 billion people living in Chinese rural areas, accounting for 17.67 % of the global rural population (The Food and Agriculture Organization (FAO, 2018). Because rural prosperity is related to the livelihood and welfare of rural inhabitants, rural development is critically indispensable in China. To improve rural development, the Chinese government proposed a new strategy of “Rural Vitalization” in 2017 that aimed to build rural areas with thriving businesses, pleasant living environments, social etiquette and civility, effective governance, and prosperity. This strategy is an updated version of the program of “Building a New Socialist

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\textsuperscript{1}Xi Jinping’s report at 19th CPC National Congress. (http://www.xinhuanet.com/english/special/2017-11/03/c_136725942.htm).

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Country-side” implemented in 2005, however, the new target of rural vitalization will inevitably put higher requirements on villages. Not all primitive villages can be hot spots for rural development in the future (Bijker and Haartsen, 2012). With poor roads, unstable water supplies, infertile land, and atrocious natural conditions, villages in deep valleys or mountainous areas are economically fragile (Liu and Li, 2017). Therefore, faced with the phenomenon of rural decline, the Chinese government must recognize that not all villages can be vitalized.

China is standing at the stage of rapid urbanization, with a total population of 1.39 billion and an urbanization rate of 58.52 % in 2017. According to the UN World Urbanization Prospects 2018, the Chinese population will reach a peak at approximately 2029, and its urbanization rate will reach 70.6 % by 2030. Then, the urban population will reach a peak of 1.09 billion by 2047, corresponding to an approximately 80 % urbanization rate. It indicates that urbanization in China is far from over, and immigration from rural areas to urban areas will continue. Therefore, it is inevitable that some villages, especially those with low development potentials, will continue to decline due to their poor conditions. Currently, there were approximately 596 thousand villages, and the number of unincorporated villages reached 3.17 million (National Bureau of Statistics of China (NBSC, 2017). Besides, Chinese villages have high diversity due to their distinct natural and social conditions (Long et al., 2009a,b). Therefore, it is highly important to explore which kinds of village can be vitalized and which can not.

In case of the less developed regions deprived of strong growth centres, a need emerged to seek endogenous potential, critical to these regions’ competitive advantage; this need in turn creates a necessity for a more individualised approach to regions and effective utilization of their internal resources (Bański and Mazur, 2016). Tackling differentiation within rural regions, applying the contemporary typologies and classifications, and putting individualised approaches into practice will definitely contribute to developing the potential and vocation of each area (Pinto-Correia et al., 2016). The implementation process about “category fist, clear target, scientific planning” is regarded as the guideline to promote rural vitalization, which was put forward by the Chinese government. Thus, it is critical to establish a diagnostic system with universality, rationality, and high efficiency to classify various villages. In Europe, the diagnostic study of Marsden showed the effects of transnational industrialization on rural development and was used to determine their development and formulate agricultural policies (Marsden, 1995, 1998; Marsden and Sonnino, 2008). After analysing the development levels of 24 agricultural systems in Europe, Marsden (1995) classified these villages into the marginal type, the production-oriented type and the integrative type based on the stage of rural development; Marsden and Sonnino (2008) classified British villages into 3 types, including pluriactivity village, agricultural centrality loss village, and sustainable village after evaluating multifunctionality and agriculture-related activities. To obtain acceptable rural migration patterns, Bijker and Haartsen (2012) evaluated the popularity degree of rural areas in the Netherlands based on the landscape, employment and accessibility, and then classified the areas into popular and less popular rural regions. Different indexes and categories were applied due to their distinct purposes. In our study, we were committed to establishing a diagnostic system to evaluate rural development potential for achieving well-organized rural vitalization.

Determined by the resources initially available, the fundamental development elements are activation of the region’s internal potential and help to achieve the goal of regional development (Mumford, 1961; Romer, 1990). Compared to simple material resources, the OECD proposed a concept of territorial capital in a regional policy context, and it has been restated: “Each region has a specific ‘territorial capital’ that is distinct from that of other areas and generates a higher return for specific kinds of investments than for others, since these are better suited to the area and use its assets and potential more effectively.” (European Commission, 2005). Camagni (2008) classified the “territorial capital” into two dimensions of rivalry and materiality, and proposed concrete factors include public goods and resources, intermediate and mixed-rivalry tangible goods; social capital; agglomeration economies, connectivity, and receptivity, etc. Among them, agglomeration effect and social network are intangible but critical for regional development on the urban-industrial economy and knowledge economy. Agglomeration effect characterized by many additional sources of productivity gain through industrial clusters can raise the probability of successful matching for all parties (Scott and Storper, 2003). Defined as the collective norms, trust, and networks of affiliation, the social network can reduce transaction costs, enhance people’s access to outsiders (Westlund, 2006). Further, the process of development is slower in an economic system developed by a single element than a system with the linkage of several elements; similar to the stories about agglomeration, linkages among elements can lead to a process of industrial concentration that is a fundamental and ubiquitous constituent of successful development in different economic systems (Fujita et al., 1999; Courtney et al., 2007). From the above, development potential depends on its affecting elements, including material and non-material aspects and endogenous and exogenous forces (Marsden, 1995; Long et al., 2009a,b; Cai and Xia, 2018). For the rural region, the so-call development elements are start-up forces that drive rural development but cannot be replicated and substituted easily, and they mainly refer to local initial resource endowment, cultural accumulation, and socioeconomic conditions. However, the disintegration of rural social network has become a common phenomenon in China due to the rural hollowing (Elshof and Bailey, 2015; Liu et al., 2011). As a public good that produces externalities for the entire economic system in a high socio-economic stage (Camagni, 2008), the social network plays a very limited role in the early stages of rural development. Therefore, rural development elements, both theoretically sound and relatively exhaustive, can be broadly summarized as (1) livelihood resource (Mumford, 1961), (2) economic circumstance (Marsden, 1995; Fieldsend, 2013), (3) cultural heritage (Gao and Wu, 2017; Lüpi et al., 2017), (4) natural landscape (Adalilar et al., 2015; Takeuchi et al., 1998), (5) location and transportation (Grunwell and Ha, 2014; Ha and Grunwell, 2011), and (6) agglomeration effects (Fujita et al., 1999; Camagni, 1991). A high level of regional potential exerts a positive influence on the creation of advantageous living conditions for the inhabitants (Bański and Mazur, 2016), while these elements bear the responsibility of improving villages from the maintenance level to the prosperity level. Previous studies have made many achievements regarding a single rural development element (Takeuchi et al., 1998; Li et al., 2014; Fieldsend, 2013); however, only a few studies have focused on the significance of the development element composite (Camagni, 2008; Tu et al., 2019), and fewer scholars devote to researching the relationship between development potential and its associated elements.

To bridge these gaps, we aim to explore how development elements influence rural vitalization potential and then establish a diagnostic system of rural vitalization, which can collate and classify the vast and complex rural system efficiently and scientifically; meanwhile, this work can also provide a basis for choosing clear targets and formulating scientific planning. Thus, our study tries to establish a diagnostic system of rural vitalization from the perspective of the message on rural development element, then to examine which villages can achieve rural vitalization, taking Dehua County, Fujian Province, as an example. It should be noted that some villages no longer have the characteristics of conventional villages because of self-urbanization or industrialization and are more similar to cities or industrial park. Cloke (1977); Cloke and Edwards (1986) and Long et al. (2009a,b) have used the rurality degree to classify the village on basis of rural representing elements of agriculture, rural population and farmland. The former classified districts into extreme rural, intermediate rural, intermediate nonrural, extreme non-rural and urban. Our discussion in this paper focuses on the three former types of rural areas.
2. Data and methodology

2.1. Data

In 2017, the government appraised approximately 3000 villages and selected 99 villages as exemplary sites for other villages to follow according to China Beautiful and Countryside Guidelines (GB/T 32000-2015). The project was jointly completed by the Ministry of Housing and Urban-Rural Development, the Ministry of Finance, the Ministry of Environmental Protection, and the Ministry of Agriculture. They demanded the selected villages need to have beautiful and pleasant natural landscapes and pastoral scenery, distinctive rural style and features, complete infrastructure, well-protected traditional culture and rural elements, a good economic development environment, and residents living and working in peace and contentment. Therefore, these villages are representative and can more fully reflect the characteristics of contemporary vitalized villages. We collected detailed information on these villages, including socio-economic data, industrial development models, geographic information, and land resource utilization, and then established a database of vitalized villages.

Official data sets, remote sensing data, and field investigation data were collected for the case study of Dehua County. The historical and cultural heritage data were obtained from the Dehua County Annals, and the socio-economic data came from the statistical yearbook. The administrative boundaries, transportation, rural settlement, and nature reserve vector data were obtained from the government. An efficient classification system was drafted to work on the remotely sensed data through human-machine interactive interpretation to guarantee classification consistency and accuracy. Then, based on Landsat 8 remote sensing image data from 2017/1/3, the land use and land cover (LULC) were classified into 6 types: construction land, farmland, grassland, forestland, water area, and unused land. Examined by high-resolution image samples from Google Earth, the accuracy of the results achieved 87.56%, meeting the requirements. The ASTER GDEM V2 digital elevation data were provided by the Geospatial Data Cloud site, Chinese Academy of Sciences (http://www.gscloud.cn).

2.2. Methodology

Projection pursuit classification (PPC) was used to determine the weights of the aggregate index in different development elements. This method is a clustering technology used to analyze and evaluate the survey data by a projection eigenvalue. It can achieve dimensionality reduction and conduct an integrated evaluation for data in low-dimensional space with the limitations of scale problems and data structure. Compared to the subjective weight and gray appraisal process evaluation method, PPC can eliminate the defect of artificial subjectivity, while compared to the entropy weight evaluation method, PPC does not have the defects of evaluation weight equalization (Fu, 2006). The construction procedure of the PPC model is as follows (Friedman and Tukey, 1974; Liu et al., 2016).

Step 1: Normalization processing of a sample evaluation index set. Supposing that the sample sets are \( x^*(i, j) = (1, 2, \ldots, n; j = 1, 2, \ldots, p) \), \( x^*(i, j) \) is the parameter value of sample i, n and p are the capacities of the sample and the index quantity, respectively. Aiming to eliminate the dimensions and unify the range of variation, it can be normalized as follows:

\[
\text{Index of positive contribution: } \text{Contribution}(i,j) = \frac{x^*(i,j) - x^{\min}(j)}{x^{\max}(j) - x^{\min}(j)}
\]

\[
\text{Index of negative contribution: } \text{Contribution}(i,j) = \frac{x^{\min}(j) - x^*(i,j)}{x^{\max}(j) - x^{\min}(j)}
\]

where \( x^{\max}(j) \) and \( x^{\min}(j) \) are the maximum and the minimum values of \( j \), respectively. The variable \( x_{ij} \) is the normalized sequence.

Step 2: Construction of the projection index function \( Q(a) \). The core thought is compressing the data into a one-dimensional projection value \( a = \{a(1), a(2), \ldots, a(n)\} \) in the direction \( z(i) \).

\[
z(i) = \sum_{j=1}^{p} a(j)x(i, j), \quad (i = 1, 2, \ldots, n)
\]

where \( a \) is the unit length of the vector. The characteristics of \( z(i) \) are that local projection points should gather as much as possible, and the projection index function can be expressed as follows:

\[
Q(a) = S_cD_c
\]

where \( S_c \) and \( D_c \) are the standard deviation and local density of the projection value \( z(i) \), respectively.

Step 3: Optimization of the projection objective function. When the sample set of each index value is given, the projection index function \( Q(a) \) only changes with the projection direction \( a \). Different projection directions show different data structure features. The best projection method is to maximize the projection direction of a certain type of feature structure of high-dimensional data. Therefore, the maximal objective function can be estimated by solving the projection index function maximization problem:

\[
\text{Max: } Q(a) = S_cD_c
\]

The constraint condition:

\[
s.t.: \sum_{j=1}^{p} a^2(j) = 1
\]

This is a complex nonlinear optimization problem with \( a(j) = 1, 2, \ldots, p \) as the optimization variable, which is difficult to address by the traditional optimization method. A quantum genetic algorithm (QGA) was used to realize high-dimensional global optimization, and the optimal projection direction was obtained by the maximum fitness function. The QGA was primarily processed by MATLAB 2016a in our study.

Step 4: Calculation of evaluation results. The best projection direction vector \( a^* \) is replaced by the \( z(i) \) formula, and the projection values of each sample point \( z^*(i) \) are obtained.

Fig. 1 presents the main workflow fluxes to establish the diagnostic system for rural vitalization. We set up the database of vitalized villages as the benchmark and direction for future rural development in China. The rural development elements were identified, and then we analyzed the relationship between the “element-composite” message and the vitalization potential as an important basis for rural vitalization. Finally, by using projection pursuit classification method, we established a diagnostic system and divided the different potentials of rural vitalization capacity.

3. Identification and analysis results of the rural “element-composite”

Considering the related information of the 99 vitalized villages and previous studies about the development element in Section 1, we determined and classified the elements into exogenous element (economic circumstance (EC)) and endogenous elements (livelihood resources (LR)), agglomeration effects (AE), location and transportation (LT), and culture/natural landscapes (CN)), and the characteristic of those were showed in Table 1. More detail standard of classification is as follows: 1) LR included farmland resources, economic forest resources, fishery resources, etc.; 2) AE includes the measure of residents living and working in peace and contentment.
resources, livestock resources, and so on; in addition, as the livelihoods of village inhabitants mainly depend on abundant LR, villages with abundant LR were regarded as having the superior condition (R); otherwise, they were regarded as general (r). 2) AE concerned whether the village had the agglomeration effect of other industries supported by resource exploitation; those with great industrial agglomeration were regarded as having solid foundations (A); otherwise, they were regarded as unstable (a). 3) LT included location information and traffic conditions; villages with a nearby national highway, a provincial highway and shipping or those close to a city were regarded as having the superior condition (L); otherwise, they were regarded as general (l). 4) CN contained elements of the human landscape and the natural ecological landscape with regional characteristics; villages with the leading enterprise of ecological or cultural tourism were regarded as the superior condition (C); otherwise, they were regarded as general (c). 5) EC referred to the social and economic levels surrounding the villages; under the pattern of urban-rural integration, regional social and economic levels could reflect the support and market demand for rural development. Based on Maslow's hierarchy of needs, with the development of economy, urban demand will gradually increase for ecological functions and cultural functions from rural systems.

<table>
<thead>
<tr>
<th>Rural development element</th>
<th>Characteristic of element</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR</td>
<td>LR is the resource in the village that can provide steadily agricultural products for farmers' survival and development. LR mainly refers to the land or water area used for agricultural production. Especially farmland, as one of the most important rural element, is a symbol of farming civilization, and it also has a strong livelihood guarantee function.</td>
</tr>
<tr>
<td>AE</td>
<td>Originating from industrial civilization, AE is an effect of industrial chain and spatial compactness that is formed based on local condition and humanist tradition. As immaterial element, AE may be expressed as a set of proximity relations which integrate a local production system, a system of actors and representations and an industrial culture, and which generates a localized dynamic process of collective learning (Camagni, 1991).</td>
</tr>
<tr>
<td>LT</td>
<td>LT reflects the natural geographical location of the village and influence communication efficiency of population, resource, and information with outsiders (local cities or neighboring villages). Limited with topography, the village located in the flat has a better LT than that in the mountain. As for the village located in the mountain, the actual distance from the outside is a lot longer than the straight-line distance, which influences the communication efficiency.</td>
</tr>
<tr>
<td>CN</td>
<td>The cultural landscape includes material and immaterial creation and value formed by time-honored history and agriculture civilization, such as historic sites, cultural activities, and folk customs. Formed in a unique physic-geographical environment with a long time, the natural landscape is considered as the resource providing aesthetic value and ecological services, including characteristic forests, rivers, lakes, and mountains.</td>
</tr>
<tr>
<td>EC</td>
<td>EC refers to the market environment and stage of social development of the region. According to the theory of economic development radiation, the urban economy has positive externalities for rural development. Based on Maslow's hierarchy of needs, with the development of economy, urban demand will gradually increase for ecological functions and cultural functions from rural systems.</td>
</tr>
</tbody>
</table>

Due to their own endogenous elements, there were 10 types of patterns identified from the 99 vitalized villages (Fig. 3). Villages with the R-a-L-C pattern accounted for 32.32 % of the total villages, followed by patterns of R-A-L-C (15.15 %) and R-a-l-C (13.13 %); there were only 2 villages of the r-a-l-C type (2.02 %), whose development only depended on outstanding cultural and natural advantages. Therefore, it is reasonable to believe that villages with single element are difficult to selected to represent the EC. From the database, we found that the urbanization rate of counties where the vitalized villages were located ranged from 38 to 82 %, and their Engel coefficients ranged from 29 to 41 %; 83.84 % of the vitalized villages presented external socio-economic levels, illustrating a clear aggregation effect (Fig. 2). Therefore, it is reasonable to consider that villages located in the county with these urbanization and Engel coefficient levels have better EC for rural vitalization.
vitalize, while these 10 types of composite villages will have more potential for vitalization. Further analysis showed that there were differences in the importance of the endogenous elements for rural vitalization. Table 2 illustrates the proportion of the villages lacking individual elements. Villages with a lack of LR accounted for only 13.13% of the total villages, followed by villages with a lack of CN (19.19%), LT (26.26%) and AE (60.61%); thus, the LR is the most indispensable element of rural vitalization, followed by CN and LT.

4. Establishing the diagnostic system and case study

4.1. The establishment of an evaluation system

Quantitative and qualitative research designs were adopted to establish the diagnostic system, which was divided into the evaluation system and the classification system. Based on the above analysis, the evaluation system of the endogenous elements is presented in Table 3. Land resources are the basis for the livelihoods of village inhabitants, so we selected land use types for the LR evaluation index according to the Land Use Status Classification in China (GB/T 21010-2017). A large income gap between urban and rural areas is an important reason for rural population loss. For the stability of rural development, it is necessary for farmers to have the same income level as urban inhabitants. Therefore, based on the theory of the human-land relationship, we used the indexes of the land carrying capacity gap to evaluate the satisfaction degree of LR. Farmland is the main source of farmers’ livelihood, and thus, we used the rate of abandoned farmland to present the use rate of LR and the agricultural development level. Culture is very difficult to measure, but public space has the function of public cultural services; thus, public space was chosen as one of the indexes for evaluating the cultural level. It should be noted that, the different indexes had different contributions to rural development, including positive and negative aspects; for example, the higher the rate of abandoned farmland was, the weaker the evaluation of the livelihood resources. The indexes are not fixed and need to be adjusted appropriately in different regions; for example, for the village that inhabitants are engaged in aquaculture, it is necessary to consider available aquaculture water into the evaluation of LR.

4.2. The establishment of a classification system

The diagnostic criteria were established to set thresholds for the results of the above evaluation system so that the results could be classified into different grades to serve as the classification system. Elements’ score interval, such as LR value distributions, could vary between regions.

The thresholds could be set by the following: (1) if the result sequence was discontinued with a clear break, the threshold value could be set as the break point; (2) if the sequence was evenly distributed and continuous, the threshold value could be set in a reasonable proportion according to the actual situation.

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Table 2
Statistics of the vitalized villages lacking a development element.

<table>
<thead>
<tr>
<th>Lacking element</th>
<th>Composite pattern</th>
<th>Proportion</th>
<th>Lacking element</th>
<th>Composite pattern</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR</td>
<td>r-A-l-c</td>
<td>4.04%</td>
<td>CN</td>
<td>R-A-l-c</td>
<td>9.09%</td>
</tr>
<tr>
<td></td>
<td>r-a-l-c</td>
<td>7.07%</td>
<td>R-A-l-c</td>
<td>4.04%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>r-a-l-c</td>
<td>2.02%</td>
<td>R-a-l-c</td>
<td>6.06%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13.13%</td>
<td>Total</td>
<td>19.19%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE</td>
<td>R-a-l-c</td>
<td>32.32%</td>
<td>LT</td>
<td>R-A-l-c</td>
<td>7.07%</td>
</tr>
<tr>
<td></td>
<td>R-a-l-c</td>
<td>6.06%</td>
<td>R-A-l-c</td>
<td>4.04%</td>
<td></td>
</tr>
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<td></td>
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</tr>
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<td></td>
<td>r-a-l-c</td>
<td>7.07%</td>
<td>r-a-l-c</td>
<td>2.02%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>r-a-l-c</td>
<td>2.02%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60.61%</td>
<td>Total</td>
<td>26.26%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Fig. 3. Ten types of “element-composite” patterns of the vitalized villages.
According to the "element-composite" message, villages with these 10 types were regarded as having a higher potential of rural vitalization capacity, while the other 6 types of villages were considered as having a lower potential. The detailed classification system is shown in Fig. 4.

### Table 3: Evaluation system of the rural development elements.

<table>
<thead>
<tr>
<th>Development elements</th>
<th>Aggregative index</th>
<th>Index interpretation and computational method</th>
<th>Positive or negative contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR</td>
<td>Rate of abandoned farmland (r1)</td>
<td>The proportion of farmland abandoned for the loss of population and productivity. The formula is as follows: ( q = 1 - \frac{D_{farm}}{R_{farm}} ) where ( q ) is the rate of abandoned farmland; ( D_{farm} ) and ( R_{farm} ) represent farmland in use and all available farmland, respectively.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Farmland carrying capacity gap (r2)</td>
<td>For achieving the average income level of urban residents, the gap between the farmland per capita in use and the farmland per capita in need was calculated. The formulas are as follows: ( Q_{farm} = \frac{D_{farm}}{p} - \frac{M}{Y_{farm}} ); ( Y_{farm} ) and ( m_{farm} ) are the unit output value and the total output value of the farmland, respectively.</td>
<td>+</td>
</tr>
<tr>
<td>AE</td>
<td>Rate of non-farm employment (a1)</td>
<td>The number of non-farm employees / the total number of employees</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Per capita household electricity consumption (a2)</td>
<td>Total electricity consumption in the village / the permanent population</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Rate of urban-rural income (a3)</td>
<td>Rural per capita net income / the urban per capita disposable income</td>
<td>+</td>
</tr>
<tr>
<td>LT</td>
<td>Proportion of non-agricultural output value (a4)</td>
<td>Production value of the rural industry and service industry / the gross value of production</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Urban proximity index (a5)</td>
<td>The index reflects urban radiation affecting rural settlement. The formula is as follows: ( D_{ti} = \sum D_{ti} ) where ( D_{ti} ) is the distance between the rural settlement and adjacent area by the area weighting method; ( d_{ti} ) represents the distance between the rural settlement of polygon i and adjacent town.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Altitude dominance index (l1)</td>
<td>The index reflects the altitude of the rural residential areas. The formula is as follows: ( H_{i} = \sum h_{i} ) where ( H_{i} ) is the altitude of the rural residential area by the area weighting method; ( h_{i} ) and ( a_{i} ) represent the altitude and rural settlement area of polygon i, respectively.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gradient dominance index (l2)</td>
<td>The index reflects the gradient of the rural residential areas. The formula is as follows: ( G_{i} = \sum g_{i} ) where ( G_{i} ) is the gradient of the rural residential area by the area weighting method; ( g_{i} ) and ( a_{i} ) represent the gradient and rural settlement area of polygon i, respectively.</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Transport accessibility index (l3)</td>
<td>The index reflects the traffic accessibility of the rural settlements. The formula is as follows: ( D_{ri} = \sum D_{ri} ) where ( D_{ri} ) is the distance between the rural settlement and adjacent arterial highway by the area weighting method; ( d_{ri} ) represents the distance between the rural settlement of polygon i and adjacent arterial highway.</td>
<td>–</td>
</tr>
<tr>
<td>CN</td>
<td>Public space (c1)</td>
<td>Includes ancient ancestral halls, religious sites, and another collective land</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Historic buildings (c2)</td>
<td>Refers to civil buildings with cultural characteristics</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Natural reserve (c3)</td>
<td>Includes biodiversity reserves, natural and human landscape reserves, wetland reserves, ecological forest reserves</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Water resources (c4)</td>
<td>Includes lakes, rivers, reservoirs and other water resources</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Cultural landscape diversity (c5)</td>
<td>Refers to the variety of ancient sites (i.e., ancient cities, villages, streets, etc.), ancient buildings (i.e., religious buildings, ancestral temples, ancient bridges, towers, pavilions, etc.), etc.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Scenic facility land (c6)</td>
<td>Refers to the construction land of scenic spots and tourist service facilities</td>
<td>+</td>
</tr>
</tbody>
</table>

**Fig. 4.** Classification system of rural vitalization.

#### 4.3. Case study of Dehua County, Fujian Province

Dehua County is the largest producer and exporter of craft ceramics in China and is named the "porcelain capital of the world". Driven by the ceramic industry, its economic development was changed from
agriculture to industry and services, with their proportions from 46:29:24 in 1978 to 5:58:37 in 2017. In the 1980s, the local government proposed the "Small county but the Big city" development strategy, which meant that limited resources and capital were pooled to address the development of urban areas. This strategy contributed to an extremely high urbanization rate (approximately 73.6 %) but also caused severe development polarization between cities and villages. This kind of development pattern is typical and universal in China.

Twelve representative villages from 9 towns were selected, considering their terrain and location as well as their social and economic levels. The LULC of Dehua County and the location of the 12 sample villages are shown in Fig. 6. The participatory rural appraisal method was adapted to investigate the status of rural development. By interviewing the elderly and cadres, the development levels of the local villages could be obtained; by interviewing farmers from different family backgrounds, the livelihoods of the peasant households were understood.

The Engel coefficients and urbanization of Dehua County are 35.2 % and 73.6 %, respectively, which are in the good condition range for EC. The evaluation results of the sample villages are shown in Fig. 5. The LR scores are distributed in two discontinuous ranges of 0.07~0.67 and 0.95~1.24; thus, the LR threshold could be set at 0.95 according to the method (1). The local land abandonment rate in the villages with superior LR included was approximately 35 %. The agricultural income per capita in these villages can reach 22,856 yuan/yr, which is slightly lower than the urban income level of 28,887 yuan/yr. With a small income gap, farmers will concentrate on rural construction, and thus this threshold was considered reasonable. The AE scores were distributed in two ranges, 0.08~0.41 and 0.83~2.00; setting 0.83 as the threshold, the villages with a solid industrial aggregation effects included Sanban village, Yangshan village and Youji village, where the average proportion of non-agricultural employment was 53.33 %, while the average outputs from non-agricultural sector accounted for 66.67 %. The LT scores were distributed in two ranges, 0.07~0.88 and 1.01~1.29; setting 1.01 as the LT threshold, the villages with superior location traffic conditions included Sanban village, Youji village, Xiayong Village, Caocun Village, Tangtou Village and Yangshan Village, Shuanghan Village and Meihu Village, having a flat terrain and accessible traffic. The CN scores were distributed in the 0.22~0.75 and 0.98~1.74 ranges; setting 0.98 as the threshold, the villages with a superior cultural and natural landscape included Xiayong village, Shuanghan village, Tangtou village, Meihu village and Nandou village. Finally, the gradation results were put into the classification system. Then, 8 types of composite patterns were diagnosed, as shown in Fig. 6 and Table 4. Dongli village, Guige village, Caocun village, Sanban village, Yangshan village and Likeng village were identified as having a low potential for vitalization. The diagnostic results of Sanban village and Yangshan village were consistent with the investigation results of the field trip; having good AE and LT conditions, these villages flourished in the industrial period; however, the potential for vitalization was weakened due to the severe destruction of LR and CN caused by predatory development.
5. Discussion

5.1. Mechanism of development elements driving rural vitalization

Starting from five dimensions of the element, the study collected 99 successful villages in China as a reference to extract endogenous and exogenous “element-composite” information of rural development, and reveal the characteristics of development elements in vitalized villages. On the basis of the information, we established a diagnostic system to evaluate the development potential of villages. In theory, the chain diagnostic framework made up from indexes to “element-composite” to development potential enriches the evaluation method of rural development potential. In practice, the diagnosis result is targeted and specific, which enables local governments and stakeholders to determine the focused areas of development in the future; the “element-composite” information can also provide the basis for selecting development patterns.

Each endogenous element has the function of rural development. Not only does LR have production function, but ecological function and landscape function (Liu et al., 2016); LT can promote the exchange of materials and information between locals and outsiders, and attract more people and capital (Ha and Grunwell, 2011); AE are major sources of growth in economies at virtually each stage of development today, as suggested by the worldwide expansion and spread of industrial clusters (Scott and Storper, 2003); With the development of tourism recently, rural CN have drawn increasing attention, and could help in achieving poverty alleviation and rural renaissance (Gao and Wu, 2017). As the Fig. 7 shows, the composite system formed by the interaction of endogenous elements provides the development foundation for individual village, which directly affects the developmental level, pattern, and path. While rural endogenous elements play an important role in the vitalization of an individual village, exogenous development elements are crucial for rural regional development. Good external economic circumstance for rural products will promote rural development.

Table 4

Composite pattern of sample villages.

<table>
<thead>
<tr>
<th>Vitanilization capacity</th>
<th>Village</th>
<th>Composite pattern</th>
<th>Vitanilization capacity</th>
<th>Village</th>
<th>Composite pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>High positivity</td>
<td>Nandou Village</td>
<td>R-a-l-C</td>
<td>Low positivity</td>
<td>Dongli Village</td>
<td>R-a-l-c</td>
</tr>
<tr>
<td></td>
<td>Xiayong Village</td>
<td>R-a-L-C</td>
<td></td>
<td>Guige Village</td>
<td>R-a-l-c</td>
</tr>
<tr>
<td></td>
<td>Tangtou Village</td>
<td>R-a-l-C</td>
<td></td>
<td>Caocan Village</td>
<td>r-a-L-c</td>
</tr>
<tr>
<td></td>
<td>Meihu Village</td>
<td>R-a-L-C</td>
<td></td>
<td>Yangshan Village</td>
<td>r-A-L-c</td>
</tr>
<tr>
<td></td>
<td>Shuanghan Village</td>
<td>R-a-L-C</td>
<td></td>
<td>Likeng Village</td>
<td>r-a-l-c</td>
</tr>
</tbody>
</table>
Regional economic circumstances are highly tied to the consumption of better ecologic environments and diverse cultures (Marsden, 1995). The degree of social development with high urbanization improved the rural plight of a large population with relatively little farmland. A total of 54 out of 99 vitalized villages in developed eastern regions with a better economic foundation demonstrated the importance of an external economic condition to rural vitalization.

Policy, capital, technology, and other applied forces from the government ensure development elements playing a role (Li et al., 2019; Fullerton, 2015; Bernard et al., 2007). As the carrier, land, the object directly affected by human intervention, reflects the characteristics of development elements. At the same time, the utilization of the elements returns to the use of land, directly guiding the local land space optimization strategy. Rationale land use planning and engineering will optimize land use structure and spatial arrangement to coordinate the “element-composite” with industry pattern (Yang et al., 2019). For rural-urban integrated development, it is necessary to propose special policies, such as land policy, financial policy, household registration policy, etc., to break the ice that only one-way flow of population, capital, and resource from rural to urban. Benefit from a prosperous external economy, capital could be invested into rural public infrastructure construction, leading to industry upgrades and habitability improvements. Externally applied forces help development elements to perform better and help development patterns work better, attracting more people and capital.

5.2. Proposals for regional land use planning and policy

China’s rural area used to pay the bill for these costs due to lacking early planning (Long et al., 2009a, b). The new strategy of “Rural Vitalization” emphasizes achieving development and prosperity across all rural areas by 2050. The planning only focusing on individual village is clearly unable to achieve this goal. However, vitalizing every village seems impossible to achieve as our result shows: Not all regions have the economic environment that can support rural vitalization, meanwhile, even for the region with a good economic condition, not all villages have a high vitalized potential. Therefore, rural vitalization planning should pursue the concept of trade-off and regional management on the basis of analysis for regional economic circumstance and resource endowment. The county territory is suggested as the scope of planning. It only needs to prepare village planning for high potential villages, rather than requiring every one. After determining the development pattern and leading industries, the land consolidation planning, ecological environmental planning, public service facilities planning, and landscape planning could be drawn up centering with industrial planning. While the low-potential villages would be arranged to maintain, merge or withdraw.

The introduction of any land use policy must be based on the full recognition of local development elements. Element development policies should first and foremost help areas to develop their capital (European Commission, 2005). In order to develop high potential villages, the land use policies should be implemented to coordinate with the development patterns. For the villages with superior LR and AE, high-efficiency agriculture or sightseeing agriculture can be selected (Lupi et al., 2017; Recasens et al., 2016) as its development pattern; therefore, to facilitate scale production, the land consolidation project needs to be launched to promote agricultural land flat and concentrated (Li et al., 2019); meanwhile, policies on the land confirmation and transfer should be applied for making full use of the spare land from migrant workers. For the village with superior CN and LT, rural tourism can be select; therefore, managers should commit to protecting cultural heritage and ecological environment; meanwhile, land policy on rural commercial collective-owned construction land into the market could be applied to promote urban-rural integration and industry amalgamation. Villages with low potential shouldn’t invest more for industrial development; reclaiming land for cultivated land dynamic balance system must be stopped in there, and returning local abandoned farmland to forests or grassland. Due to a lack of development elements and severe rural decline, we suggest the villagers of Likeng Village immigrate to the others with great population carrying capacity through the aid and prod of the government (Li et al., 2014). Then the original villages return to green spontaneously, creating a good ecological environment for the whole region. For Dongli Village and Guige Village which have superior LR only, we recommend satisfying villagers’ high demand for agricultural machinery and basic medical service because of serious aging. Sanban Village and Yangshan Village have similar “element-composite” of r-A-L-c. We suggest the former to integrate into the city for urbanization because of a small quantity of farmland and adjacent to the city; but for the latter, that with serious farmland pollution and landscape destruction, we propose to launch the soil remediation and ecological remediation project for improving LR and CN condition, and development potential further. Limited by the deficiency of elements and too small territorial area, the managers could merge Caocun Village with neighbor Tangtou Village for joint
development.

5.3. Limitations and further perspectives

There are still some limitations in our study. Due to practical constraints, our study was based on limited successful cases in China, but it can, to some extent, reflect the requirement of the development elements for rural vitalization. The capable persons (human capital) with entrepreneurship, creativity, and private know-how are always recognized as the important foundation of rural development (Camagni, 2008). However, due to the serious outflow of rural population happens in Chinese countryside, it is difficult to count and evaluate this element; we think it is inaccurate to identify the capable persons by academic qualifications, while other indicators of evaluating agricultural capacity are difficult to quantify, therefore, this element is not included in the diagnostic system, but it needs further improvement. The innovation of this paper lies in the identification of the "element-composite" message of rural development, which not only serves to diagnose the potential of rural vitalization but also guides villages to formulate a vitalization model for further land use planning. Therefore, we also hope to make a more detailed scheme in the next study to serve the development of rural areas.

6. Conclusions

Determining the potential of rural vitalization and establishing a classification system are crucial for a rural vitalization strategy in China. We established the framework of a rural vitalization diagnostic system based on the database of vitalized villages and then took Dehua County as our case study. The conclusions are as follows:

- LR, AE, LT, and CN were identified as the endogenous development elements, and EC was the exogenous element. Successful villages with a lack of LR, CN, LT, and AE accounted for 13.13 %, 19.19 %, 26.26 %, and 60.61 % respectively, therefore, LR is considered the most indispensable endogenous element, followed by CN, LT, ET, EC. The important element for evaluating the external market demand and degree of social development, and those villages had better external economic conditions, with their urbanization rate of 38~82 % and their Engel coefficient of 29~41 % in the counties. In addition, we believe that it is difficult to vitalize villages with only one development element; the pattern of "element-composite" directly influenced its rural vitalization potential. Ten types of composite patterns were considered to be useful for promoting rural development in China at present. The R-a-L-C (32.32 %) and R-A-L-C (15.15 %) with the highest proportion, we found, are the greatest potential patterns for vitalization; and the proportion of former lacking AE condition is more than the latter, which proves again the low importance degree of AE.

- Taking 12 villages in Dehua County as an example, the result shows that half of them had low potential. We hope that the Chinese government can attach importance to the rural "element-composite" and give priority to developing villages with high vitalization potentials.

The developmental level and pattern are determined by exogenous element composite, characterizing land use structure and spatial arrangement. For the villages with high potential, land development policies (policies with a land approach to development) should first and foremost help areas to develop their development elements. Land use planning must be coordinated with the developmental pattern, and targeted investment and land engineering project are also essential. For the villages with low potential, the government doesn’t have to formulate rural vitalization plan and arrange to maintain, merge or withdraw on the basis of element condition. Meanwhile, because the endogenous elements could be influenced by external economic conditions, the government should also pay more attention to external economic development in economically underdeveloped areas.

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