

Agricultural Production Evaluation and Spatial Correlation Analysis of Townships in Hainan Island

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Abstract—Using principal component analysis, natural breaks, spatial correlation analysis methods, based on the status evaluation, spatial differentiation and correlation of agricultural production of 195 townships in Hainan Island were analyzed, so as to provide a reference for formulating scientific township agricultural plans and policies. The results show that: (1) Townships with better agricultural production are located in cities and counties with better agricultural development. The major factors that affect agricultural production are area of cultivated land, area of facility agriculture, and the proportion of employees in primary industry. (2) Above 45% of townships in the first three levels of agricultural production are distributed in eastern and western cities and counties, and 50% in the fourth level are distributed in central cities and counties. (3) There are spatial agglomerations in areas with similar agricultural production. Meanwhile, some suggestions were put forward to promote the development of agricultural production in Hainan Island.

Keywords—agricultural production evaluation of townships; principal component analysis; natural breaks; spatial correlation analysis; suggestions

I. INTRODUCTION

Agriculture is an important industrial sector of the national economy, and agricultural development is an important support for rural revitalization. As the most advanced grassroots organization in the divisions of administrative areas in China, townships are the basis and focus for solving the problems of agriculture, rural areas and farmers, and balancing urban and rural development. Hainan Province is an important production base of winter melon and vegetable, natural rubber base, southern breeding and producing seed base, tropical fruit and flower base, aquaculture and marine fishing base and regions that are free from specified animal epidemics. Studying the location and spatial correlation of agricultural production in each township in Hainan Island is crucial to manage agricultural problems in contiguous areas adapting to local conditions, and promote rural revitalization. At present, a large number of scholars have studied the spatial distribution characteristics of regional agricultural development. Xu Lian [1] used principal component analysis method to carry out comprehensive evaluation and cluster analysis of agricultural economic development level of counties in Xinjiang, and map spatial differentiation of development level. Guoping Zeng et al. [2] used spatial measurement methods to analyze and study the

spatial correlation, agglomeration characteristics and spatial dynamic evolution trend of agricultural economic development of 31 provinces and regions in China; Jiangxia Hu et al. [3] used geostatistical analysis tools to analyze the overall and partial spatial layout of agricultural development of the 22 districts and counties in Chongqing section of the Three Gorges reservoir area. Most of the scholars have carried out research on regional agricultural production from geographic units at the provincial and county level, and there are few at township level. There is no quantitative research on the agricultural production from geographic units at the township level in Hainan Island. Therefore, with the differences and spatial correlations of agricultural production in Hainan Island as the starting point, the principal component analysis and exploration spatial data analysis methods were used to evaluate status of agricultural production in Hainan Island and analyze its spatial distribution characteristics. Then some suggestions for promoting the agricultural production development of townships in Hainan Island were put forward to provide reference for government decision-making department.

II. DATAS AND METHODS

A. Research Area

Hainan Island is located on the northern edge of the tropics, which has a tropical monsoon climate. The surrounding area of Hainan Island is low and flat, the middle is high, the east is humid, and the west is semi-dry. Hainan Island has an annual average temperature of 22 to 26 degrees centigrade, and annual average rainfall of above 1500 mm, which is known as the "natural greenhouse". The research area involves 195 townships in 17 cities and counties including Haikou City, Wuzhishan City, Wenchang City, Qionghai City, Wanning City, Ding'an County, Tunchang County, Chengmai County, Lingao County, Danzhou City, Dongfang City, Ledong County, Qiongzhou County, Baoting County, Lingshui County, Baisha County and Changjiang County. The spatial and geographical differentiation of townships has formed the differentiation of agricultural production of townships in Hainan Island to a certain extent.

B. Data Source and Index Systems

Following the basic principles of science, system, comprehensiveness and accessibility, 8 indicators are selected

to constitute evaluation index system (TABLE I) including area of facility agriculture, irrigated area of cultivated land, sown area of farm crops, sown area of grain crops, the proportion of employees in the primary industry, number of agricultural technical service agencies, and number of farmer cooperative. By the index system, the agricultural production status of townships in Hainan Island are evaluated, the data used are from “Hainan Township Statistical Yearbook 2017”.

TABLE I. EVALUATION INDEX SYSTEM OF AGRICULTURAL PRODUCTION OF TOWNSHIPS IN HAINAN ISLAND

Target layer	Indicator layer
Agricultural production	Area of cultivated land(hectare)
	Area of facility agriculture (hectare)
	Irrigated area of cultivated land (hectare)
	Sown area of farm crops (hectare)
	Sown area of grain crops (hectare)
	The proportion of employees in the primary industry (%)
	Number of agricultural technical service agencies (PCS)
	Number of farmer cooperative (PCS)

C. Research Methods

1) *Principal component analysis (PCA)*: PCA is a multivariate statistical method for dimension reduction that reduces multiple variables into a few principal components (Namely, integrated variables). These principal components can reflect most of the information about the original variables and they are irrelevant, which is useful for analyzing and modeling the problems.

There are many variables about agricultural production development of townships, and the correlation between variables is obvious, which means that some information repeatedly affects. It is easier to get the main influencing factors of agricultural production differences by using PCA. In this paper, the theoretical derivation of PCA is omitted here, but the detailed steps [4] for the application of PCA with MATLAB software are introduced as follows:

- Standardize the raw data;
- Calculate a matrix R of sample correlation coefficients;
- Calculate the eigenvalues of matrix R and corresponding eigenvectors;
- Select the important principal component and write the principal component expression

$$F=\lambda_1X_1+\lambda_2X_2+\dots+\lambda_nX_n \quad (1)$$

Where F represents the score of a single principal component, λ represents the eigenvector of the corresponding principal component, X represents the standardized variables of raw data;

- Calculate the scores of each principal component;
 - Conduct comprehensive evaluation based on the contribution rate of each principal component.
- 2) *Natural breaks (Jenks)*: Natural breaks classification is that set classification breaks on the natural separation between

data packets, and each classification spacing can have its own width, and the number of features in each classification is also different. Statistically, it can be measured by variance. By calculating the variance of each classification and the sum of these variances, the sum of variance is used to compare the quality of the classification. The smallest value is the optimal classification result, that is the theory of Natural breaks classification. This method works well to processing unevenly distributed data, and there are small differences within the classification and large differences between classifications, resulting in an obvious break between each classification and clustering well. These make it the default choice of classification scheme for ArcGIS [5].

3) *Spatial autocorrelation analysis*: Spatial autocorrelation analysis is an important indicator to measure the degree of interdependence between data at a certain location and data at the other locations, including global spatial autocorrelation and local spatial autocorrelation. The global spatial autocorrelation uses the Global Moran's I index to measure the interrelationship of spatial elements. When the z-score or p-value indicates statistical significance, if the Moran's I index value is positive the clustering trend is indicated; if the Moran's I index value is negative the dispersion trend is indicated. The calculation method is as follows:

$$\frac{\sum_i \sum_j \omega_{ij} (x_i - \bar{x})(x_j - \bar{x}) / \sum_i \sum_j \omega_{ij}}{\sum_i (x_i - \bar{x})^2 / n} \quad (2)$$

Where x_i and x_j respectively represent the combined scores of township i and township j, \bar{x} is the average comprehensive scores of all townships, n represents the number of townships, and ω_{ij} represents the spatial weight matrix. Local autocorrelation compensates for the neglect of regional heterogeneity by global autocorrelation. Anselin local Moran's I is used to identify spatial clustering and spatial outliers of high or low value elements with statistically significant [6-7].

III. RESULT AND ANALYSIS

A. Evaluation of Agricultural Production of Townships in Hainan Island

The main component analysis is carried out by using MATLAB software with the index data reflecting the agricultural production situation of 195 townships in 2017, and the retention rate of principal component information is set to 90%. As shown in TABLE II, the information content of the first six principal components has accounted for 96% of the total information, which is highly representative of the original data. According to the principal component score coefficient matrix, the linear combination expression of the first six principal components is written as follows:

$$\begin{aligned} F_1 &= 0.4253X_1 + 0.2307X_2 + 0.4588X_3 + 0.5008X_4 + 0.4820X_5 - \\ &\quad 0.1431X_6 + 0.1655X_7 + 0.1561X_8 \\ F_2 &= -0.4932X_1 - 0.0036X_2 - 0.4409X_3 + 0.3079X_4 + 0.3144X_5 - \\ &\quad 0.3609X_6 - 0.1127X_7 + 0.4751X_8 \end{aligned}$$

$$F_3=0.0422X_1-0.4259X_2-0.0774X_3+0.2685X_4+0.3349X_5+$$

$$0.6219X_6-0.4848X_7-0.0694X_8$$

$$F_4=0.1580X_1+0.5012X_2+0.1279X_3-0.1679X_4-0.2079X_5+$$

$$0.0410X_6-0.6883X_7+0.4008X_8$$

$$F_5=-0.1792X_1+0.4750X_2-0.1597X_3+0.1917X_4+0.1725X_5-$$

$$0.1496X_6-0.2671X_7-0.7460X_8$$

$$F_6=-0.2330X_1+0.5298X_2-0.1488X_3+0.0605X_4+0.0302X_5+$$

$$0.6611X_6+0.4168X_7+0.1659X_8$$

According to the linear combination expression of above six principal components, the scores for six principal components of agricultural production of each township in Hainan Island can be calculated. Then the comprehensive scores for agricultural production of each township are obtained through evaluated, and the scores and rankings are shown in TABLE III.

TABLE II. CHARACTERISTIC VALUE AND CONTRIBUTION RATE OF PRINCIPAL COMPONENTS

Component	Characteristic value	Contribution rate	Cumulative contribution rate
1	2.7668	0.3458	0.3458
2	1.2359	0.1545	0.5003
3	1.0651	0.1331	0.6335
4	0.9658	0.1207	0.7542
5	0.8468	0.1058	0.8600
6	0.7998	0.1000	0.9600
7	0.2209	0.0276	0.9876
8	0.0990	0.0124	1.0000

According to the comprehensive scores of 195 townships in Hainan Island in 2017, the three townships with the highest agricultural production scores are Basuo Town, Jinjiang Town, and Ligu Town, separately located in Dongfang City, Chengmai County, and Ledong County. In 2017, the Agricultural output value of Ledong County was 8.542 billion yuan, accounting for 80.15% of the total output value of agriculture, forestry, animal husbandry and fishery in Ledong County, ranking first in Hainan Island. The agricultural output value of Chengmai County was 5.789 billion yuan, accounting for 48.46% of the total output value of agriculture, forestry, animal husbandry and fishery in Chengmai County, ranking fourth in Hainan Island. The agricultural output value of Dongfang City was 4.982 billion yuan, accounting for 71.40% of the total output value of agriculture, forestry, animal husbandry and fishery in Dongfang City, ranking eighth in Hainan Island. The agricultural development of the above cities and counties is better, the wide area of cultivated land and good location conditions of the three townships have accelerated their agricultural development. The three townships with the lowest scores are Haixiu Town, Yinggehai Town, and Chengxi Town, separately located in Haikou City, Ledong County and Haikou City. These townships have very little cultivated land, Chengxi Town is the last, and Yinggehai Town is the third last, and Haixiu Town is the eleventh to last, which restricts their agricultural development. The industry, hotels and catering services of Chengxi Town develop rapidly. Yinggehai Town

mainly develops industry. Haixiu Town is located in the suburb of Haikou City, whose hotels and catering services develop better.

B. Spatial Pattern of Agricultural Production of Townships in Hainan Island

With the method of Natural breaks classification, the situation of agricultural production of townships can be divided into four levels in Hainan Island, whose spatial pattern is drawn by ArcGIS software as shown in FIGURE I. The 1st level includes 11 townships, and the proportion of townships in the east, west and central regions respectively are 27%, 55% and 18%. The eastern townships are mainly distributed in Wanning City and Wenchang City, the western townships are mainly distributed in Dongfang City, Ledong County, Chengmai County and Danzhou City, and the central townships are mainly distributed in Ding'an County. The 2nd level includes 41 townships, and the proportion of townships in the east, west and central regions respectively are 37%, 51% and 12%. The eastern townships are mainly distributed in Wanning City and Haikou City, the western townships are mainly distributed in Ledong County, Chengmai County and Danzhou City, and the central townships are mainly distributed in Tunchang County. The 3rd level includes 73 townships, and the proportion of townships in the east, west and central regions respectively are 45%, 37% and 18%. The eastern townships are mainly distributed in Wenchang City, Qionghai City and Haikou City, the western townships are mainly distributed in Danzhou City, Chengmai County, Changjiang County and Lingao County, and the central townships are mainly distributed in Ding'an County and Tunchang County. The 4th level includes 70 townships, and the proportion of townships in the east, west and central regions respectively are 33%, 17% and 50%. The eastern townships are mainly distributed in Haikou City, the western townships are mainly distributed in Lingao County, and the central townships are mainly distributed in Baisha County, Baoting County, Qiongzong County and Wuzhishan City. Overall, the number of townships in the east and west is more in the first three levels, while the number of townships in the central region is more in the fourth level. The development of agriculture has a tendency of good development in the periphery and backward development in central region.

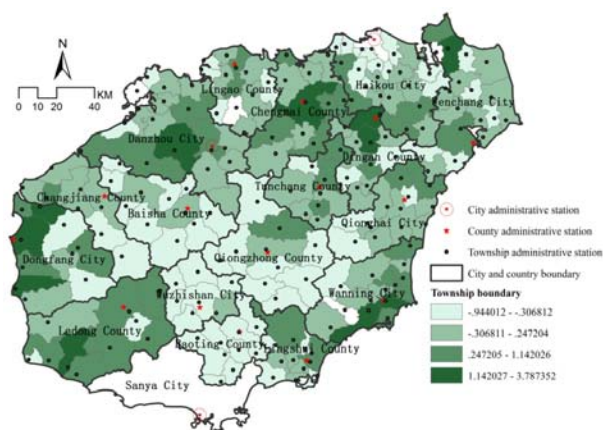


FIGURE I. SPATIAL PATTERN OF AGRICULTURAL PRODUCTION OF TOWNSHIPS IN HAINAN ISLAND

TABLE III. COMPREHENSIVE SCORES FOR AGRICULTURAL PRODUCTION OF 195 TOWNSHIPS IN HAINAN ISLAND

Name	Score	Name	Score	Name	Score	Name	Score	Name	Score	Name	Score
Jinjiang Town	3.7874	Sigeng Town	0.4393	Wupo Town	0.1099	Donglu Town	-0.1502	Diaolou Town	-0.3405	Changzheng Town	-0.6051
Liguo Town	2.9300	Longgun Town	0.4370	Guangcun Town	0.0927	Dongge Town	-0.1639	Yongxing Town	-0.3437	Bangxi Town	-0.6114
Basuo Town	2.6132	Wanling Town	0.4296	Changfeng Town	0.0902	Heqing Town	-0.1657	Xixiu Town	-0.3447	Maodao Township	-0.6175
Gancheng Town	1.6120	Qiaotou Town	0.4278	Baoluo Town	0.0890	Yinggen Town	-0.1756	Limushan Town	-0.3448	Zhongping Town	-0.6209
Leiming Town	1.5797	Jiazi Town	0.4170	Xincun Town	0.0770	Qifang Town	-0.1823	Changliu Town	-0.3525	Xinying Town	-0.6339
Dingcheng Town	1.5151	Donghe Town	0.4100	Shilu Town	0.0739	Tian'an Township	-0.1840	Huiwen Town	-0.3663	Liugong Township	-0.6371
Sanjia Town	1.4458	Yaxing Town	0.3951	Wangwu Town	0.0504	Bo'ao Town	-0.1848	Qicha Town	-0.3672	Nanbao Town	-0.6378
Liji Town	1.3469	Hele Town	0.3858	Fuwen Town	0.0478	Hanlin Town	-0.2051	Fengpo Town	-0.3776	Lingshan Town	-0.6403
Dacheng Town	1.3294	Yelin Town	0.3851	Longhu Town	0.0432	Longguang Town	-0.2068	Zuntan Town	-0.3857	Xishui Township	-0.6539
Wancheng Town	1.3022	Longmen Town	0.3845	Fushan Town	0.0309	Chongxing Town	-0.2131	Timeng Township	-0.3946	Longtang Town	-0.6573
Jinshan Town	1.2914	Haitou Town	0.3737	Haiwei Town	0.0225	Xinzhou Town	-0.2182	Fanyang Town	-0.4265	Eman Town	-0.6585
Jiusuo Town	1.1420	Zhongxing Town	0.3705	Zhongyuan Town	0.0190	Duowen Town	-0.2201	Qingsong Township	-0.4297	Heping Town	-0.6587
Foluo Town	1.1238	Puqian Town	0.3083	Yacha Town	0.0138	Wanquan Town	-0.2215	Datian Town	-0.4322	Rongbang Township	-0.6694
Wulie Town	1.0448	Changpo Town	0.3039	Lanyang Town	0.0100	Heshe Town	-0.2420	Jiamao Town	-0.4488	Jiangbian Township	-0.6753
Sanmenpo Town	0.9491	Shishan Town	0.2846	Fengmu Town	0.0033	Yangjiang Town	-0.2431	Longhe Town	-0.4693	Baocheng Town	-0.6826
Ruixi Town	0.8761	Xinlong Town	0.2846	Baimajing Town	-0.0041	Chahe Town	-0.2431	Zhaling Town	-0.4739	Qunying Township	-0.6854
Huangliu Town	0.8747	Benhao Town	0.2682	Zhonghe Town	-0.0046	Tanniu Town	-0.2432	Sangengluo Town	-0.4775	Shuiman Township	-0.6943
Yongfa Town	0.8121	Wenru Town	0.2662	Wengtian Town	-0.0074	Sancai Town	-0.2514	Xinzheng Town	-0.4859	Nanlin Township	-0.6986
Hou'an Town	0.7481	Nada Town	0.2547	Changhua Town	-0.0184	Yunlong Town	-0.2602	Diaoluoshan Township	-0.4976	Xiangshui Town	-0.7073
Dalu Town	0.7131	Shiyuetian Town	0.2472	Mutang Town	-0.0259	Wenluo Town	-0.2643	Huangzhu Town	-0.5026	Zhayun Township	-0.7177
Tuncheng Town	0.7120	Laocheng Town	0.2345	Bohou Town	-0.0434	Longjiang Town	-0.2734	Maoyang Town	-0.5200	Li'an Town	-0.7239
Xinxing Town	0.6587	Nansheng Town	0.2234	Dongying Town	-0.0483	Nanqiao Town	-0.2798	Penglai Town	-0.5260	Yuanmen Township	-0.7260
Baoyou Town	0.6513	Longquan Town	0.1888	Beida Town	-0.0560	Shangen Town	-0.2808	Sanjiang Town	-0.5264	Jinbo Township	-0.7375
Qianjia Town	0.6413	Banqiao Town	0.1880	Jiuzhou Town	-0.0689	Nanfeng Town	-0.2982	Da'an Town	-0.5305	Maogan Township	-0.7881
Lincheng Town	0.6102	Yanfeng Town	0.1685	Longlou Town	-0.0833	Changsa Town	-0.3002	Shang'an Township	-0.5441	Nankai Township	-0.7888
Wencheng Town	0.5702	Xinpo Town	0.1587	Jiale Town	-0.1008	Yingzhou Town	-0.3068	Gongpo Town	-0.5522	Fulong Township	-0.7956
Zhizhong Town	0.5443	Poxin Town	0.1541	Tanmen Town	-0.1073	Tongzha Town	-0.3091	Paipu Town	-0.5527	Wangxia Township	-0.8745
Nanlv Town	0.5379	Jiaji Town	0.1512	Nankun Town	-0.1083	Huangtong Town	-0.3150	Changhao Township	-0.5681	Haixiu Town	-0.8761
Wanchong Town	0.5215	Hongqi Town	0.1405	Xinzhu Town	-0.1134	Wenjiao Town	-0.3207	Sandao Town	-0.5745	Yinggehai Town	-0.8873
Dongcheng Town	0.5069	Lingkou Town	0.1364	DongjiaoTown	-0.1170	Taya Town	-0.3235	Huishan Town	-0.5845	Chengxi Town	-0.9440
Guangpo Town	0.4960	Renxing Town	0.1281	Dafeng Town	-0.1280	Xichang Town	-0.3262	Longqiao Town	-0.5845		
Dongshan Town	0.4911	Damao Town	0.1227	Dapo Town	-0.1328	Shibi Town	-0.3304	Da'an Town	-0.6000		
Dong'ao Town	0.4470	Jianfeng Town	0.1164	Bolian Town	-0.1463	Dazhipo Town	-0.3356	Hongmao Town	-0.6009		

C. Spatial Correlation Analysis of Agricultural Production of Townships in Hainan Province

1) *Global spatial autocorrelation:* With the global Moran's I index, we analyze the global spatial correlation of township agricultural production. In 2017, the global Moran's I index of township agricultural production is 0.2371, the z-score is 5.8894, and the P-value is 0, which indicate that the agricultural production situation of townships in Hainan Island is positively correlated with the spatial distribution, and spatial agglomeration occurs in areas with similar development. That is to say, in the townships with better agricultural production, the agricultural production in nearby townships is also better, and vice versa.

2) *Local spatial autocorrelation:* With the anselin local Moran's I tool, the clustering map for township agricultural production of Hainan Island in 2017 is drawn, and the spatial autocorrelation is further analyzed, as shown in FIGURE II. The High-High region includes 14 townships, mainly concentrated in the area bordering Chengmai County, Ding'an County and Haikou City. The Low-Low region includes 5 townships, mainly distributed around the administrative center of Haikou City, and the area of Dongfang city away from the coastal to the central part. There are 2 townships in the High-Low region, mainly concentrated in Ledong County and Dongfang City. There are 4 townships in the Low-High region, mainly concentrated in Dongfang City and Ledong County.

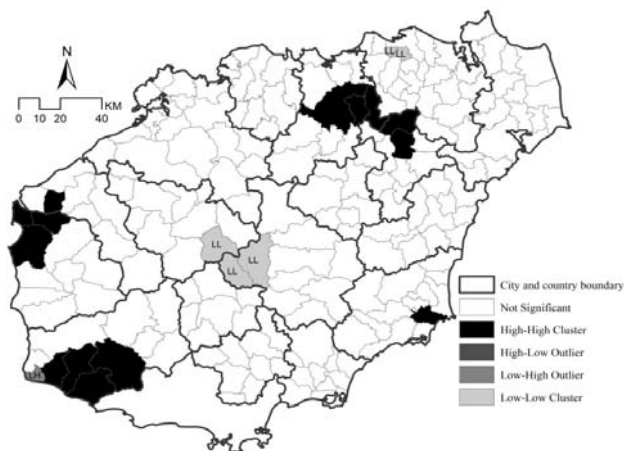


FIGURE II. LISA CLUSTER MAP OF AGRICULTURAL PRODUCTION OF TOWNSHIPS IN HAINAN ISLAND

D. Conclusion

Seen from the above analysis, we can get the following conclusions:

a) The townships with better agricultural production are mostly located in Chengmai County, Danzhou City, Wanning City, Wenchang City and Dongfang City, which have better agricultural development. The factors that have a greater impact on the development of agricultural production are the area of cultivated land, the area of facility agriculture and the proportion of employees in the primary industry.

b) In Hainan Island, more than 50% of townships in the first level are distributed in the western cities and counties. More than 50% of townships in the second level are also distributed in the western cities and counties. 45% of townships in the third level are distributed in the eastern cities and counties. 50% of townships in the fourth level are distributed in the central cities and counties. Most of townships in the eastern and western are distributed in the first three levels, while most of townships in the central region are distributed in the fourth level.

c) The agricultural production situation of townships in Hainan Island is positively correlated with spatial distribution, and there is spatial agglomeration in areas with similar development. The townships of High-High cluster are mainly distributed in the area bordering Chengmai County, Ding'an County and Haikou City. The townships of Low-Low cluster are mainly distributed around the administrative center of Haikou City and the area of Dongfang City away from the central part of the coastal area.

IV. SUGGESTIONS ON THE DEVELOPMENT OF AGRICULTURAL PRODUCTION OF TOWNSHIPS IN HAINAN ISLAND

A. Strengthening the Construction of Townships Infrastructure

The township department in Hainan Island should strengthen the infrastructure construction of township social development, break the barriers to urban and rural talent mobility, and improve the quality of township agricultural talents. Strengthening the infrastructure construction of township production is helpful to improve production efficiency. Strengthening the construction of township transportation facilities can help improve the efficiency of agricultural products transportation and the speed of inter-connectivity between townships.

B. Exploiting the Advantages of Cultivated Land According to Local Conditions

It is helpful to make full use of existing cultivated land resources, which can actively exert the agriculture production potential of townships with large-scale farmland, accelerate the adjustment of industrial structure, plant superior crops, break the boundaries of counties, concentrate on developing facilities agriculture, increase effective irrigation area, and create efficient agriculture.

C. Actively Promoting the Development of Integrated Industries Such as Leisure Agriculture and Rural Tourism

The township department should actively explore agricultural culture, developing leisure agriculture, rural tourism and other integrated industries, which are good for solving the employment problem of township labor and conducive to personnel and information exchange in urban and rural. Obviously, these are helpful to promote agricultural brands, inherit agricultural culture and expand agricultural functions, so as to improve the comprehensive benefits of agriculture and achieve sustainable development of agriculture.

D. Accelerating the Development of Ecological Recycling Agriculture

Taking ecological recycling agriculture as an important direction to transform agricultural production mode, the township should focus on supporting ecological agriculture recycling projects, comprehensive utilization of livestock and poultry waste, livestock and poultry standardized breeding projects, arable land protection and upgrading projects, etc. which will promote the organic development of agriculture and upgrade supply quality and efficiency of agricultural products.

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REFERENCES

- [1] X. Lian, Evaluation and spatial differentiation of county - level agricultural economy development in Xinjiang, *Journal of Arid Land Resources and Environment*, vol. 30, pp. 73-81, 2016.
- [2] G. P. Zeng, H. Y. Luo and Y. Q. Cao, Spatial distribution and correlation of agriculture economic development in China: Based on the panel data in 1985-2008 of 31 provinces, autonomous region and municipality, *Journal of Hunan Agricultural University(Social Sciences)*, vol. 11, pp. 1-6, 2010.
- [3] J. X. Hu and C. H. Wen, Study on spatial distribution characteristics of agricultural development in the Three Gorges Reservoir Area, based on the statistical analysis of geography, *Journal of Henan Agricultural University*, vol. 50, pp. 248-253, 2016.
- [4] J. W. Zhuo, Application of MATLAB in Mathematical Modeling, Beihang University Press, September 2014.
- [5] [US] Price, Y. L. Li, etc. ArcGIS Geographic Information System Tutorial (Fourth Edition), Electronic Industry Press, September 2009.
- [6] B. Meng, J. F. Wang, W. Z. Zhang and X. H. Liu, Evaluation of Regional Disparity in China Based on Spatial Analysis, *Scientia Geographica Sinica*, vol. 25, pp. 11-18, 2005.
- [7] J. Lian, X. J. Li, H. L. Gong and Y. H. Sun, Analysis of Agricultural Economy Spatial Characteristics of Beijing Townships Based on ESDA, *Areal Research and Development*, vol. 29, pp. 130-135, 2010.