

Analyzing Influencing Factors of Rural Poverty in Typical Poverty Areas of Hainan Province: A Case Study of Lingao County

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Abstract: Rural poverty and poverty reduction are not only the focal issues that have attracted worldwide attention, but also the vital issues on people's livelihood that has attached great importance and aimed to be solved by the central and local governments of China. Based on the survey data of 354 farming households, this paper, taking the national poverty county of Lingao County, Hainan Province for an example, examined the characteristics of rural poverty of the county. Moreover, this paper established the spatial lag model (SLM) from five dimensions, namely, status of the household head, household structure, health status, income composition and traffic accessibility, to analyze the main influencing factors of rural poverty according to the values of Moran's *I* and the diagnosis of spatial dependence of the OLS model. It is found that the poor farming households gathered mainly in five towns in the north and southwest of the county, and the rural poverty have the characteristics of low educational level of the heads, more minor children, high population of farming peasants, high incidence of disease and low proportion of household wage-equivalent income. The results also showed that the variables such as the number of minor children, the number of migrant worker, the number of farming peasants and the proportion of wage-equivalent income have significant effectiveness on rural poverty, while the status of the household head, health status and traffic accessibility have little influence. It is an important way to realize the goal of poverty alleviation by controlling the number of farmers' fertility, strengthening the vocational skills training of farmers, vigorously developing specialization and large-scale agriculture and increasing the employment opportunities of farmers.

Keywords: rural poverty; targeted poverty alleviation; spatial lag model; Lingao County, China

Citation: ZHANG Jinping, ZUO Feng, ZHOU Yanmei, ZHAI Mengxiao, MEI Lin, FU Yidi, CHENG Yeqing, 2018. Analyzing Influencing Factors of Rural Poverty in Typical Poverty Areas of Hainan Province: A Case Study of Lingao County. *Chinese Geographical Science*, 28(6): 1061–1076. https://doi.org/10.1007/s11769-018-1008-9

1 Introduction

Poverty remains a problem worldwide (Mani et al., 2013; Haushofer and Fehr, 2014; Zhang et al., 2015; Song et al., 2017), and poverty reduction is the focal issue that has attracted worldwide attention. Since the 1960s, the developing countries have implemented series of anti-poverty programs for the rural poverty reduction, such as credit poverty alleviation programs,

technological and industrial poverty alleviation programs, public works programs, early childhood development programs, nutrition programs, basic education programs, health & medical health programs, social security programs, etc. However, the implemented effectiveness of these programs has significantly different among the countries and regions, and the problems of global poverty are still outstanding. Therefore, in September 2000, the 'United Nations Millennium Declara-

Received date: 2018-02-02; accepted date: 2018-06-01

Foundation item: Under the auspices of National Natural Science Foundation of China (No. 41661028), Natural Science Foundation of Hainan (No. 417099), Science and Technology Plan Project of Colleges and Universities of Shandong (No. J14LH04)

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tion' passed an action program aiming at reducing the global poverty by half by 2015 (at the 1990 level). The United Nations also officially launched the '2030 Sustainable Development Agenda' in January 2016, and the first sustainable development goals of which is to eliminate all forms of poverty around the world. Besides, in 2016, the World Bank's 'Poverty and Shared Prosperity report' noted that despite there is a weak global economic growth, people living in extreme poverty in the world decline continuously and decreased by about 100 million in 2012–2013, which owes to the contribution of poor population reduction in China and other countries of Asia-Pacific regions. At present, there are still half of the world's extremely poor people living in the sub-Saharan Africa and one third in the South Asia (Gao, 2016).

Rural poverty is also a vital issue on people's livelihood that has attached great importance and aimed to be solved by the central and local governments of China. Since the reform and opening up, China's rapid growth of rural economy has improved the farmers' income and living standard greatly, and the situation of rural poverty has also achieved remarkable progress with the continuous propulsion of poverty alleviation. Particularly, the central government of China implements the anti-poverty program in the new century that takes the villages as the basic unit and focuses on the whole village advancement, labor training and transfer, agricultural industry development and voluntary immigration poverty alleviation. A comprehensive pattern of poverty reduction has been developed in basic education, basic medical services and social security in China. However, the rural poverty has not been solved fundamentally for the implementation of these policies, which is still the most prominent 'short board' that restricts the rapid development of China's economy and society. By the end of 2015, there were still 56.3 million registered rural poor populations in China, and the incidence rate of poverty in most central and western provinces was higher than 10.0%, especially, eight ethnic provinces of which exceeded 12.1% (China State Council, 2016). Therefore, the Chinese central government implements the strategy of targeted poverty alleviation vigorously and formulates a comprehensive goal of poverty alleviation, that is, the rural poor people will not worry about eating and wearing and their compulsory education, basic medical and housing security will be guaranteed by

2020. Successfully, China has reduced 10 million rural poor people and achieved significant effectiveness in poverty reduction in 2016. However, with the in-depth propulsion of targeted poverty alleviation, China is facing with such outstanding issues as deeper poverty degree, higher cost of poverty reduction and greater difficulty in poverty alleviation, which can not be solved relying on the conventional measures. Therefore, in the context of big downturn pressure and regional differentiation of current economic development, the theoretical and empirical researches should be strengthened on the problems and influencing factors of rural poverty in China and the typical regions. It can not only provide scientific reference for policies making of targeted poverty reduction and effective improvement of poverty reduction, but also has great practical significance for the realization of '2030 Sustainable Development Agenda' and the sustainable development of rural areas in China.

In recent years, serious concerns about poverty and poverty reduction have been raised in academia, and a large body of theoretical and empirical literatures attempting to describe and explain the characteristics, patterns, influencing factors and policies of the global, regional and local poverty problems. The theoretical studies paid more attention to the impact of economic growth, infrastructure investment, income distribution and social equity on poverty, especially emphasized the influence of the policies implemented on poverty and the effective evaluation of poverty reduction (Loayza and Raddatz, 2010; Bagchi and Svejnar, 2015; Lenz et al., 2017). Besides, series of literatures focalized on the relationship of poverty and such factors as food security, energy and fuel, race and ethnicity, social security, and public health (Brummett et al., 2011; Arcanjo et al., 2013; Mitra et al., 2013; Sovacool, 2015; Win, 2015; Damaske et al., 2017; Joshi et al., 2017), and the children and aged people were the main group. The empirical studies paid attention to the measurement of multi-dimensional poverty based on field survey data (Sadath and Acharya, 2017), as well as the status and causes of poverty and measures of poverty reduction in urban or rural areas (Keet et al., 2015; Ward and Shackleton, 2016; Arouri et al., 2017). Moreover, increasing achievements kept their eyes on the scale of households and even individuals of communities/villages, and focalized on the multi-dimensional analysis of influencing

factors of rural poverty on the base of farming household survey data. For example, Ren et al. (2017) analyzed the spatial pattern and influencing factors of the incidence rate of poverty of China's 13 poverty-stricken areas in 2013 using multi-level model, and found that there existed a significant negative correlation between the incidence rate of poverty and the income, urbanization, education, food production and the proportion of irrigated land, while the regional differences of each factors on the incidence rate were large. Cao et al. (2016) identified the influencing factors on the poverty level of farming households in Liangshan Yi Autonomous Prefecture in China using the complete two-tier linear model, and found that the scale and educational level of labor force, housing area and value, costs of medical treatment and disaster losses were the key variables affecting the vulnerability of poverty at household level. Based on the NCAER-collected household panel survey data, Dhamija and Bhide (2013) found that the impact of village-level infrastructure, household size and composition, and economic growth on poverty varied with time in different periods of rural India, and argued that the implementation of poverty reduction strategies must take the changing economic environment into account. Gounder (2013) simulated the correlation of household consumption and poverty in Fiji using the farmer's survey data, and argued that such three measures as improvement of the rural education level, rural supporting policies of agricultural growth and reallocating of labor force to regular economic sectors will effectively reduce poverty of farming household. Using descriptive statistics and FGT's P alpha poverty measurement method, Kwaghe and Amaza (2008) examined the impact of economic-related factors on poverty of 360 households in Bono, Nigeria, and found that 18% of the farming households were seriously poor, and then suggested that poverty reduction policies should be made to let the farmers easier access to agricultural loans and means of production, and encourage farmers to engage in non-farm industries and diversify the agricultural activities. Using the data from three family groups in rural Bangladesh from 1991 to 2001, Khandker and Koolwal (2010) found that irrigation, paving roads, erecting electricity and increasing credit channels led to higher agricultural and non-agricultural incomes, but these measures did not reduce the poverty of the poorest families significantly. Weber et al. (2005) established a method-

ology that might limit the validity of existing research findings based on the critical review of the literatures, and examined whether there were these rural areas beyond the demographic characteristics and local economic background in the United States that made poverty become more likely. In addition to the studies of multidimensional influencing factors, the impact of such single factor as child disability risk (Mugoya and Mutua, 2015), urbanization (Cali and Menon, 2013), transport infrastructure (Guo et al., 2014), microcredit (Chinonso and Justice, 2017) and income distribution (Fosu, 2010) on rural poverty has also attracted increasing concerns, as well as the impact of policies and institutions on rural poverty and their effectiveness on rural poverty reduction.

From the above review, it is not difficult to find that in-depth studies have been made on the theory of poverty, and the global, regional and local empirical researches based on macroeconomic data or micro-survey data have also provided scientific basis and useful reference for making the policies of poverty reduction and regional sustainable development from different scales and perspective. However, the existing literatures paid more attention to the poverty problems of the Third World countries, particularly in southern Africa and South-East Asia (Kim et al., 2016; Ward and Shackleton, 2016). The problem of poverty in the Third World countries is a great deal of homogeneity and regional poverty, which requires the implementation of large-scale and mass-scale poverty reduction policies. At present, China has departed from this stage. However, the causes of poverty vary widely and are facing a deeper poverty alleviation situation. Therefore, it is necessary to implement a precise poverty alleviation strategy that aims at giving solutions to every household in every village. Until now, the studies of poverty in China focalized on the macro scale of the spatial pattern, measurement of poverty and incidence rate of poverty, and the relationship between the macroeconomic strategy of the government, economic growth and investment and poverty (Chen et al., 2016; Liu and Xu, 2016; Liu et al., 2017), but lacked the enough empirical studies of local poverty problems and influencing factors of rural poverty in typical case based on household survey data. Besides, the traditional metrological model used in the studies of rural poverty took the research units as independent and homogeneous individuals and assumed

that there is no spatial association and autocorrelation between the interfering items. However, according to the first law of geography, the adjacent spatial objects have similar spatial value. Therefore, the traditional metrological model has weak reliability to explain the spatial problems.

Hainan Province lies in the southernmost tip of the Chinese mainland, with a total of 35 400 km² land area and about 2 million km² sea area. It is the largest province in China and comprised of such island reefs and water areas as Hainan Island, Xisha Islands, Zhongsha Islands and Nansha Islands. The resident population of Hainan Province was 9.17 million in 2016, of which the rural population accounted for 43.22%. The per capita GDP was 44 252 yuan (RMB), which was 18% lower than that of the national level. By the end of 2016, there were five and six key counties included in the national and provincial plan for poverty alleviation, respectively, and covers 6000 households and 477 000 registered rural poor population, which not only has become a major obstacle to realize the grand goal of building a well-off society, but also does not match the major strategy of 'building a beautiful new Hainan' in the period of the thirteenth five-year plan. Lingao County was designated as one of these major counties included in the national plan of poverty alleviation in 2012, where is one of the counties that has a relatively short period of time in state-level poverty-stricken counties, larger incidence rate of poverty and deeper levels of poverty degree in Hainan Province, as well as the outstanding characteristics of slow economic development, poor industrial base and weak rural infrastructure construction. By the end of March 2016, there were 11419 households and 51093 rural poor populations in the county, and the amount of the poor population accounted for 16% of the Hainan Province. The incidence rate of poverty was 14.2%, which was 2.6 times of that in Hainan Province, and the rural poverty has a more outstanding and concentration of spatial characteristics. Therefore, this paper, taking Lingao County as an example, analyzed the characteristics of rural poverty based on farming household survey data, and then examined the main influencing factors on rural poverty using the spatial statistical analysis method that can describe the relationship and the degree of association of the spatial factors, aiming at providing scientific basis for policies making and effective promotion of poverty reduction in Lingao County, which is also of

great reference value to the practice of targeted poverty alleviation and socioeconomic sustainable development for the similar areas in Hainan Province.

2 Study Area and Data Resources

Lingao County lies in the northwest of Hainan Island, and covers a total land area of 1317 km² and 376 km² of the sea area. It is comprised of 10 towns, 1 farm and 176 villages and neighborhood committees. Lingao County belongs to the Qiongbai platform with gentle terrain, and is slowly tilted from south to north. The south and southeast of the county is hilly, and the central and northwest is river plains and sea plains. The altitude of the platform is between 50 and 100 m, and the altitude of the mountain is below 306 m. Most of the land is red soil effloresced from basalt, following is the sandy soil developed from the shallow sediments and river alluvial. The land has deep soil, more organic matter, good soil fertility and good water irrigation conditions, and teems with grain, sugar, oil, fish, pigs, salt and tropical fruits, which makes Lingao County became one of the key counties of agriculture and fishery development in Hainan Province. Besides, it has high temperature, rainy climate and adequate light. The average temperature in January and July is 16.9°C and 28.3°C, respectively. Its mean annual rainfall days are 135.9 with 1417.8 mm rainfall, and the rainy season is from May to October, the rainfall of which accounts for 85% of the whole year. It is one of the west counties that suffers relative weak impact of typhoon in Hainan Province, and has just an average of 3.1 times of strong winds per year with 3.5 m per second of average annual wind speed. Lingao County is one of the less developed areas in Hainan Province, with 512 000 populations and 31 050 yuan (RMB) of per capita GDP in 2016, which is 30% lower than that of the average level of Hainan Province. The composition of the tertiary industries of Lingao County and Hainan Province was 70.1 : 6.3 : 23.6 and 24.0 : 22.3 : 53.7, respectively, indicates that the industrial structure of Lingao County is not reasonable and has a great gap with the province. Besides, the per capita disposable income of urban residents and rural residents was 24 000 yuan (RMB) and 10 678 yuan (RMB), respectively, both of which are lower than the average level of the province.

In order to understand the situation of the poor

households and identify the influencing factors of rural poverty, a micromesh questionnaire was redesigned based on the original questionnaire of the Third-party assessment on the effectiveness of targeted poverty alleviation in China, which paid more attention to the China's targets of poverty reduction in 2020 and the key contexts of the international anti-poverty program, and took the socioeconomic development and cultural background of Hainan into account at the same time. Such contexts were included in the questionnaire as the situation of the head of the poor households, basic livelihood status of the farmers, household structure, educated condition of the children, income structure, medical treatment, housing security and implemented effectiveness of the major policies on poverty reduction.

The field investigation and questionnaire survey were conducted from January 14th to 20th in 2017. Firstly, we selected 5 towns and 7 villages as the sample areas according to the incidence rate of poverty, size and spatial distribution of the poor population, location characteristics and the geographical environment of the poor villages in Lingao County (Fig. 1, Table 1). And then, we sampled the amounts of the surveyed poor population according to the statistical sampling standard of two in a thousand. At the same time, we also sampled randomly the lists of the surveyed poor households of each sampled poor village according to the list of registered poor households provided by the Poverty Alleviation Office of Hainan Province in 2016. Finally, we achieved the survey data of a total of 354 poor households utilizing the method of door-to-door questionnaire survey and face-to-face in-depth interview.

Analyzing the results of the questionnaire survey and

interview of the poor households (Table 1), it can be found that rural poverty in Lingao County presents the following characteristics. Firstly, the nature of rural poverty is regional and holistic, and the spatial agglomeration of poor households is obvious. Secondly, the poor households have a relatively high Engel coefficient, and have a higher proportion of expenditure in food, tobacco and alcohol at the lower income level of households. Thirdly, the heads of poor household have a lower level of education, and most of the poor households have abundant but poor-quality labor force. Fourthly, most of the poor households have a larger size, minor children and patients or disabled persons. Therefore, the proportion of poor households is high due to the education, disease and disability. Finally, the willingness of some poor households that rely on their own

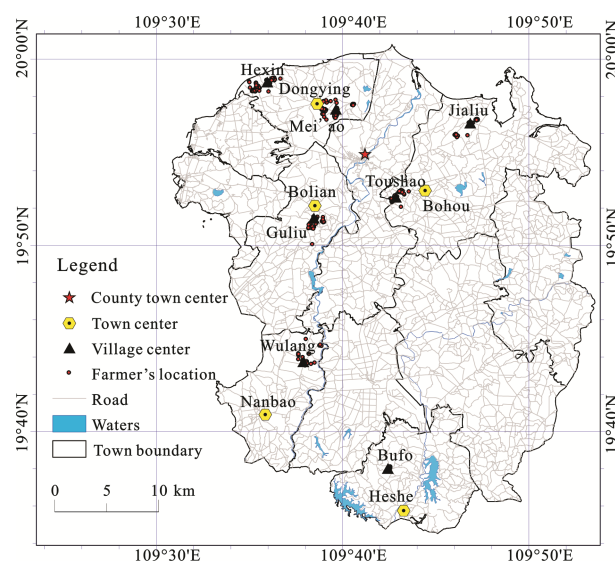


Fig. 1 Location of Lingao County and distribution of sample areas

Table 1 Sampling results and farmer's attributes

Town	Village	Samples (households)	Household size (persons per household)	Average labor force (persons per household)	Household with minor children (households)	Poverty due to disease (households)	Poverty due to disability (households)	Average per capita net income (yuan (RMB))
Dongying	Hexin	80	5.26	2.83	49	41	19	2857
	Meiao	84	5.06	2.55	47	40	12	2965
Bolian	Guliu	48	5.04	3.25	22	4	4	5951
Bohou	Jialiu	52	4.42	2.08	28	36	1	1657
	Toushao	45	4.71	2.60	24	37	5	1395
Nanbao	Wulang	27	4.56	2.63	23	17	6	1711
Heshe	Bufo	18	4.39	2.67	14	4	1	2772
Total (average)		354	(4.78)	(2.66)	207	179	48	(2758)

Note: The poverty line of Hainan Province was 2965 yuan (RMB) in 2016

efforts to get rid of poverty is not strong enough influenced by the local culture and traditional lifestyle. Facing this condition of rural poverty, we can not help thinking two questions, namely, what factors influence rural poverty? And what degree of influence are the factors on rural poverty? A further analysis will be conducted to answer these questions.

3 Methodology

3.1 Indicators

The incidence of poverty is due to the low level and narrow source of income, and it is reasonable to use income as the indicator to depict poverty. Therefore, in this study, the per capita net income of household was selected as the dependent variable to examine the main influencing factors of rural poverty in Lingao County. Analyzing the questionnaires of the poor households in 2016, it can be found that the surveyed households were able to maintain the basic livelihood and needed not worrying about eating and wearing. The minor children of the poor households could complete the nine-year compulsory education and get enough nutrition benefit from the nutrition improvement program implemented by the governments to the rural compulsory education. Besides, the housing security situation of the poor households was identified one by one, and almost all the dilapidated houses were transformed or rebuilt with the special funds arranged by the government. These conditions indicated that there is no significant difference among the poor households in basic livelihood condition, children's education and housing security. Therefore, this study mainly examined the influence of such five dimensional factors as the status of the household head, household structure, health status, and income structure and traffic accessibility on rural poverty, and 15 specific indicators were selected as the independent variables (Table 2). The descriptive statistics of non-dummy variables are shown in Table 3.

The Moran's I of the per capita net income households is 0.2887 ($P = 0.000$) and is statistically significant, indicating that the per capita net income of the households tends to be spatial agglomeration and exists spatial autocorrelation. Therefore, it is reasonable to examine the influencing factors of rural poverty using spatial regression model in this study. In theory, these households with female or senior or low-education-level

head of household are prone to poverty. Households with more elderly people or minor children are prone to poverty. Households with students in the non-compulsory education stage need to pay the increasing educational expenditure and are possible to poverty. Households with large farming population or small migrant workers are not easy to escape poverty. Households with the members suffering from severe or chronic diseases or with disabilities are more likely to fall into poverty. In addition, households with high proportion of operational income or low proportion of wage-equivalent income are prone to poverty. The worse the accessibility of households to the administrative village center, the town center, or the county town center, the more the households are prone to poverty. Therefore, we prejudge the sign of each independent variable on the dependent variable (Table 2). According to the statistical results of the questionnaires (Table 1), the poor households in Lingao County have the characteristics of low educational level of the household head, large numbers of minor children, more farming peasants and less migrant workers, more households with patients, low proportion of wage-equivalent income and big difference of traffic accessibility to the county town center. Thereby, the indicators of x_3 , x_5 , x_7 , x_8 , x_9 , x_{12} , x_{15} were assumed to be the significant variables that affect rural poverty.

3.2 Calculation method of traffic accessibility

Rural transport infrastructure has a positive or negative impact directly or indirectly on poverty reduction (Guo et al., 2014). Based on the high-quality village-level highway network data and using the calculation method of grid accessibility, this paper calculated the minimum time cost from the arbitrary grid in the study area to the node of the nearest administrative village, small town and county town, respectively. Specifically, the study area was divided into 150 m \times 150 m grid and different surface types and different grades of the road were given a different speed and then the average travel time of 150 m was calculated (Table 4). The basis values of the time cost of the main spatial objects are: a) Land. The continuous part of the land outside the road can travel in any direction and is assigned to 3 km/h walking speed; b) Waters. Considering the main waters of the land area in Lingao County do not have the capacity of access, the average speed is set to 0; c) Road. Travel speed of the

Table 2 Variables and the calculation methods

Dimensions	Variables (unit)	The representation and calculation of variables	Prejudgment of the sign
Status of the household head	Gender	x_1 : Dummy variable, male 1, female 0	+
	Age (years)	x_2 : Actual age of the head of household	–
	Educational level	x_3 : The educational level of the household head is 1 for the illiterate and the primary school, 2 for the junior high school, 3 for the high school, secondary school and vocational school, and 4 for the university and above	+
Household structure	Number of old people (persons)	x_4 : Population over 60 years old	–
	Number of minor children (persons)	x_5 : Population under 16 years of age	–
	Non-compulsory education students	x_6 : Dummy variable, household with non-compulsory education students assigned to 1, otherwise assigned to 0	–
	Number of farming peasants (persons)	x_7 : Number of labor force as farming peasants	–
	Number of migrant workers (persons)	x_8 : Number of labor force as migrant worker	+
Health status	Disease	x_9 : Dummy variable, household with severe disease or chronic disease assigned to 1, otherwise assigned to 0	–
	Disability	x_{10} : Dummy variable, household with disabled person assigned to 1, otherwise assigned to 0	–
Income structure	Proportion of operational income (%)	x_{11} : The proportion of household operational income accounted for the net income	–
	Proportion of wage-equivalent income (%)	x_{12} : The proportion of household wage-equivalent income accounted for the net income	+
Traffic accessibility	Accessibility to administrative village center (min)	x_{13} : The time cost of the households to the center of the administrative village	–
	Accessibility to town center (min)	x_{14} : The time cost of the households to the town center	–
	Accessibility to county town center (min)	x_{15} : The time cost of the households to the county town center	–

Table 3 Descriptive statistics of non-dummy variables

Variables	Minimum	Maximum	Mean	Median	SD
y	–887	23040	2848.38	2286.50	2526.047
x_2	24	94	53.56	52.5	13.889
x_3	1	4	1.66	2	0.682
x_4	0	3	0.67	0	0.829
x_5	0	6	1.86	2	1.278
x_7	0	6	1.89	2	1.112
x_8	0	4	0.50	0	0.859
x_{11}	–143.9	100	28.36	20.75	31.975
x_{12}	0	115	46.75	51.25	34.531
x_{13}	1.1	17.4	5.85	6.21	3.026
x_{14}	6.3	31.0	18.94	19.52	6.088
x_{15}	10.7	69.7	27.66	24.82	13.395

Table 4 Values of time cost for main spatial objects

Spatial objects	Land	Waters	Expressway	National highway	Provincial highway	Ramp	Urban road	County road	Township road	Village road
Speed (km/h)	3	0	100	70	50	30	30	40	30	20
Time cost (min)	3	–	0.09	0.13	0.18	0.3	0.3	0.23	0.3	0.45

expressway, national highway, provincial highway is set according to the industrial standard of ‘Highway Engineering Technology Standard’ (JTGB01-2003) of the People’s Republic of China and combined with the ac-

tual situation of the region; d) Other roads. Travel speeds of other grade of roads are set according to the designed speed and the actual situation from the survey. Furthermore, the vector element layer respectively of

the extracted spatial elements were established according to the value of time cost, and the spatial elements were converted into grid layers to overlay, and then the grid accessibilities of the households to the node of the nearest administrative village, town and county town were calculated using the cost distance module of spatial analysis in ArcGIS software.

3.3 Spatial regression model

Generally, if there exists spatial autocorrelation (spatial dependence) of the per capita net income among households, and Moran's I of the residual of the OLS model is statistically significant, the spatial regression model can be used to explore the impact of each variable on poverty based on the traditional econometric model. In this study, the OLS regression model was used to test the relationship between variables of different dimensions and poverty, and variables of each new dimension were introduced successively to observe the change of the main influencing factors of poverty. If there is spatial autocorrelation for the residuals of the OLS model, the spatial lag model (SLM) (spatial lag of the dependent variable is introduced) (Equation 1) or the spatial error model (SEM) (spatial lag of error is introduced) (Equation 2) is used to express the quantitative relationship of poverty and the key influencing factors according to the results of statistical test. The equation is given as follows:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \beta_{k+1} W_{ij} Y_j + \varepsilon \quad (1)$$

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon, \varepsilon = \lambda W_{ij} \varepsilon + \xi \quad (2)$$

where Y_i is the natural logarithm of per capita net income of the household i ; β_0 is the constant term; $\beta_1, \dots, \beta_{k+1}$ are regression coefficients; X_k is the k -th independent variable in Table 2, where $X_2, X_{11}, X_{12}, X_{13}, X_{14}, X_{15}$ are the natural logarithm of original variables respectively. In Equation 1, it is assumed that there is a spatial dependency among the dependent variables, which results in the occurrence of the autocorrelation of residuals. That is, the per capita net income of the household i is affected by the per capita net income of the neighboring household j . So, the lag of the dependent variable $W_{ij} Y_j$ is introduced into the model, and W_{ij} is the spatial weight matrix. In Equation 2, it is assumed that the attribute of the spatial unit itself causes the spatial autocorrelation of the residual, rather than the attribute of the per capita net income variable of the neighboring

household, and the error term ε is added to the model after weighting through the spatial weight matrix.

4 Results and Analyses

4.1 Model design and optimization

The statistical characteristics of the variables showed that the five dimensions factors were related to the incidence of rural poverty. Thereby, the empirical analysis is needed to identify which variables are significantly related to poverty, and how much of their impacts on poverty. In this study, four sets of models were established to examine the influencing factors of rural poverty. The aim was to observe the changes of the variables affecting rural poverty by gradually introducing variables of each dimension. The parameters and test results of the model are shown in Table 5. It can be found that the Moran's I of the residual in the OLS model of each set of models is significantly positive, indicating that there is spatial autocorrelation of the residuals. Therefore, it is necessary to use the spatial regression model to analyze influencing factors of rural poverty. According to the value of Lagrange multiplier (LM) and its test, and combining the values of LM (lag) and LM (error), SLM with large LM value was selected to analyze results in each set of model. From comparative analysis of the values of the R^2 , Log likelihood, AIC and SC, we can conclude that the effect of the SLM is better than that of the OLS model.

Model 1 only considers the influence of two dimensions of the status of the household head and household structure. The results showed that there was an unobvious negative correlation between gender, age and educational level of the heads and poverty, while the number of minor children and migrant workers had a significant negative impact on poverty.

Model 2 introduces the dimension of health status based on Model 1. It can be found that the significance of the variables in Model 1 did not change clearly. The new variable of disease had a significant negative effect on poverty in OLS model, but its significance decreased after considering the spatial effect.

Model 3 introduces the dimension of income structure based on Model 2. It can be found that the impact of the variables of the status of heads was still not significant. The impact of the number of minor children and migrant workers and the new variable of the proportion

Table 5 Estimates of factors affecting rural poverty

Variables/ Parameter	Model 1		Model 2		Model 3		Model 4	
	OLS	SLM	OLS	SLM	OLS	SLM	OLS	SLM
x_1	-0.0116 (0.917)	-0.0007 (0.994)	-0.0119 (0.913)	-0.0021 (0.983)	-0.0421 (0.680)	-0.0314 (0.748)	-0.0399 (0.696)	-0.0329 (0.737)
$\ln x_2$	-0.0672 (0.731)	-0.0291 (0.873)	0.0311 (0.873)	0.0139 (0.940)	0.1090 (0.548)	0.0868 (0.617)	0.0736 (0.687)	0.0828 (0.636)
x_3	-0.0241 (0.683)	-0.0393 (0.475)	-0.0350 (0.548)	-0.0425 (0.441)	-0.0217 (0.689)	-0.0291 (0.576)	-0.0246 (0.652)	-0.0286 (0.584)
x_4	-0.0471 (0.431)	-0.0553 (0.321)	-0.0398 (0.499)	-0.0513 (0.357)	0.0038 (0.946)	-0.0096 (0.855)	0.0047 (0.932)	-0.0088 (0.868)
x_5	-0.1168*** (0.000)	-0.1070*** (0.000)	-0.1229*** (0.000)	-0.1105*** (0.000)	-0.1292*** (0.000)	-0.1188*** (0.000)	-0.1308*** (0.000)	-0.1199*** (0.000)
x_6	0.0225 (0.818)	-0.0066 (0.942)	-0.1242 (0.243)	-0.0650 (0.520)	-0.0389 (0.696)	-0.0005 (0.996)	-0.0309 (0.758)	0.0013 (0.989)
x_7	-0.0422 (0.244)	-0.0461 (0.172)	-0.0412 (0.249)	-0.0447 (0.186)	-0.0853** (0.012)	-0.0835** (0.010)	-0.0886*** (0.009)	-0.0841** (0.010)
x_8	0.2844*** (0.000)	0.2034*** (0.000)	0.2532*** (0.000)	0.1964*** (0.000)	0.1563*** (0.001)	0.1212*** (0.008)	0.1494*** (0.002)	0.1201*** (0.009)
x_9			-0.3172*** (0.000)	-0.1426* (0.098)	-0.1990** (0.018)	-0.0728 (0.382)	-0.1705** (0.048)	-0.0708 (0.401)
x_{10}			-0.0279 (0.809)	0.0289 (0.791)	0.0062 (0.954)	0.0478 (0.641)	-0.0045 (0.966)	0.0456 (0.658)
$\ln x_{11}$					-0.0481 (0.566)	-0.0484 (0.546)	-0.0473 (0.573)	-0.0478 (0.551)
$\ln x_{12}$					8.0260*** (0.000)	0.0920*** (0.000)	0.0992*** (0.000)	0.0919*** (0.000)
$\ln x_{13}$							0.0073 (0.875)	-0.0072 (0.873)
$\ln x_{14}$							-0.1936 (0.113)	-0.0264 (0.832)
$\ln x_{15}$							-0.1142 (0.243)	-0.0255 (0.790)
Constant	8.4617*** (0.000)	3.4274*** (0.001)	8.3031*** (0.000)	3.7822*** (0.001)	8.0260*** (0.000)	4.5056*** (0.000)	8.3485*** (0.000)	4.5877*** (0.000)
W_lny	—	0.6156*** (0.000)	—	0.5614*** (0.000)	—	0.4443*** (0.000)	—	0.4366*** (0.000)
R^2	0.1538	0.2427	0.1850	0.2468	0.2990	0.3328	0.3047	0.3328
F-statistic	7.8366*** (0.000)	—	7.7860*** (0.000)	—	12.1207*** (0.000)	—	9.8742*** (0.000)	—
Moran's I (error)	0.1030*** (0.000)	—	0.0606*** (0.000)	—	0.0388*** (0.000)	—	0.0335*** (0.000)	—
Log likeli- hood	-384.691	-367.321	-378.036	-365.840	-351.366	-343.584	-349.924	-343.534
AIC	787.382	754.643	778.072	755.680	728.732	715.167	731.847	721.069
SC	822.206	793.336	820.634	802.111	779.033	769.337	793.756	786.847
LM (lag)	123.6827*** (0.000)	—	59.2612*** (0.000)	—	27.9711*** (0.000)	—	21.8126*** (0.000)	—
LM (error)	95.9707*** (0.000)	—	33.2140*** (0.000)	—	13.6215*** (0.000)	—	10.1513*** (0.001)	—

Notes: The values outside the brackets are the estimated coefficients of the variables, and the values in the brackets are the P values under the coefficients; ***, ** and * are significant at 1%, 5% and 10%, respectively

of wage-equivalent income on poverty was extremely significant. And the number of farming peasants has significant negative impact on poverty. Besides, the effect of the disease was significant in the OLS model but was not significant in the SLM.

Model 4 takes the impact of traffic accessibility into account based on Model 3, that is, this model includes all dimensional variables. It can be found that the significance and influence degree of the variables in the original model 3 did not change remarkably, and the newly introduced variables of accessibility of households to the center of the village, town and county town did not pass the test of significance.

Comparatively analyzing the four sets of models, we can find the Model 4 that includes the whole 5-dimensional variables are more moderation and has better explanation forces than other three sets of models. The estimates and test results of model 4 showed that households with the more minor children or farming peasants were more possibly falling into poverty and those with the more migrant workers and high wage-equivalent income were more likely increasing the per capita net income. The impact of disease on poverty in the OLS model was more significant than that in the SLM, and the impact of the status of the household head and traffic accessibility on poverty was not significant in both the OLS model and the SLM. The most important factors that influence rural poverty are from the dimensions of the household structure and income structure.

4.2 Factor interpretation

4.2.1 Household structure

Seeing from the age structure of the household members (Fig. 2), households without elderly people and with non-compulsory education students account for 56% and 21% of the surveyed households respectively. The

30% of the households do not have minor children, but 49% of those have two or three minor children. The average dependency ratio of the elderly people was 0.284, while the average child support ratio was 0.599. Households do not have much pressure to support the elderly people, and overmuch minor children restrict rural poverty reduction in Lingao County. Seeing from the perspective of the labor force, the households that the number of farming peasants is much higher than that of the migrant workers, and there are 179 households whose total labor force are farming peasant, accounting for 51% of the total samples. The overmuch numbers of farming peasant and too small numbers of migrant workers restrict the increasing of households' income, and have an important impact on rural poverty in Lingao County. It is consistent with prejudgment that the number of both the minor children and farming peasants of the households have negative impact on rural poverty and the number of migrant workers has significant positive impact.

4.2.2 Income structure

The income sources of the surveyed households in Lingao County are relatively simple, most of which depends mainly on the operational income of the cultivation and livestock breeding. However, the overall operational income is low and there is a large variation among households (Fig. 3). The operational income of 27 households is negative. Households that the proportion of operational income are less than 30% and more than 50% account for 50% and 21% of the total samples, respectively. Thus, in general, the proportion of operational income was relatively low and has insignificant impact on poverty. Most of the surveyed households have low proportion of wage-equivalent income in Lingao County. Among the 354 surveyed households, there are 94 households that the proportion of wage-equivalent

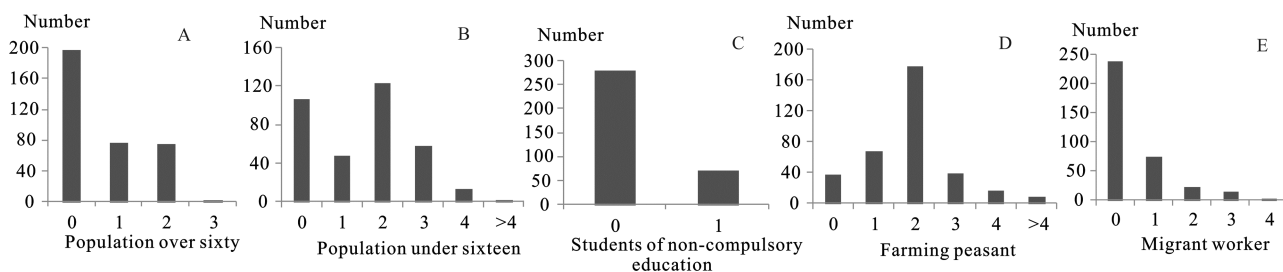


Fig. 2 Household structure. A: 0–3 means there are 0 to 3 people aged over sixty in a household in the left figure; B: 0–4 and >4 mean there are corresponding number of people aged under sixteen in a household; C: 0 means there are no non-compulsory education students, whereas 1 means there are students in the non-compulsory education stage in a household. D: 0–4 and >4 mean there are corresponding number of farming peasants in a household; E: 0–4 means there are corresponding number of migrant workers in a household

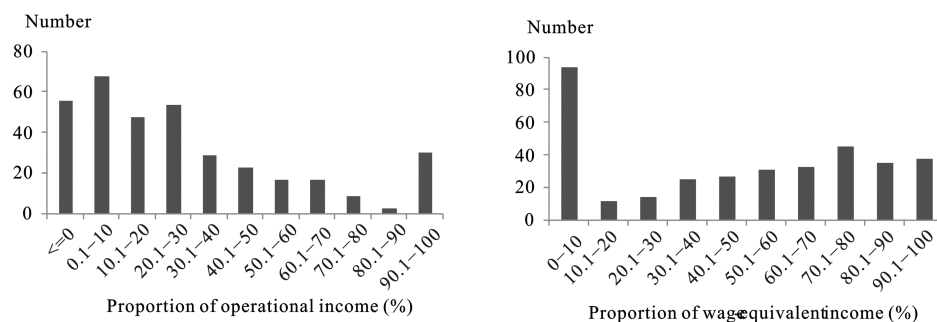


Fig. 3 Income structure. The horizontal axis number indicates proportion of operational income of a household is negative or between 0.1% and 10%, 10.1% and 20%, ..., 90.1% and 100% in the left figure; the horizontal axis number indicates proportion of wage-equivalent income of a household is between 0 and 10%, 10.1% and 20%, ..., 90.1% and 100% in the right figure

income is less than 10% and 172 households that the proportion of wage-equivalent income is less than 50%, accounting for 27% and 49% of the total samples, respectively. The proportion of wage-equivalent income has significant positive relationship with poverty, which is consistent with the prejudgment.

4.2.3 Status of the household head

The household head is the most important manager and decision maker in households and has decisive affect to the economic condition and likelihood of the households. In theory, households that the heads are aged and low educational female are more likely falling into poverty. However, evidence of household poverty in rural areas such as age and gender of the household head remains unclear. For example, Sy (2013) finds that older households tend to correspond to larger household size, but age has less impact on rural poverty than urban households. Altamirano Montoya and Teixeira (2017) found that female-headed households are not necessarily poorer due to the heterogeneity of rural households. The statistical analysis showed that the age and gender of the household head in Lingao County have insignificant influence on poverty, and the simulation results of spatial regression model do not match the prejudgment. Fig. 4 shows that 85% of the household heads are male, and households that the age of the heads are between 40 and 60 years account for 51% of the total samples and often have a larger household size. There is no significant difference between female and elderly headed households in terms of income level and life style with those of male and young head of household. Education plays an important role in getting rid of poverty in the rural areas of Liangshan Yi Autonomous Prefecture in China (Cao et al., 2016). However, the impact of education on rural poverty in Lingao County is not obvious in this study,

which is inconsistent with the prejudgment. Most of the heads have low educational level, and 89% of whom do not receive the education of high school (secondary school, vocational school) and above. The main reason is that the data in this study are randomly selected poor households rather than randomly sampled households in the entire Lingao County. Among the 38 households whose head have received high school education or above, only 16 households have higher per capita net incomes than the poverty line, which cannot reflect the impact of education on poverty alleviation compared with other education-level farmers. In addition, average household size surveyed is 4.9 and the average labor force is 2.7, and larger household size and relatively abundant labor force, to some extent, inhibit the significant impact of the quality of the household head on poverty.

4.2.4 Health status

It can be seen in Fig. 5, households with severe or chronic diseases and disabled people account for 51% and 14% of the total samples, respectively. The overmuch poor health of the members may lead the household fall into poverty. However, the impact of disease and disability on rural poverty in Lingao County is insignificant, which is not consistent with the prejudgment. It is attributed to the increasing input and in-depth reform of the rural medical and health implemented by the central and local governments of China since 2015, in the context of the implementation of the targeted poverty alleviation strategy. Objectively speaking, the poor households enjoyed less preferential policies on the reimbursement of medical treatment and disability subsidies before 2015, and the high cost of medical treatment caused a large body of households suffering from poverty due to disease and disability. Hereafter, with the

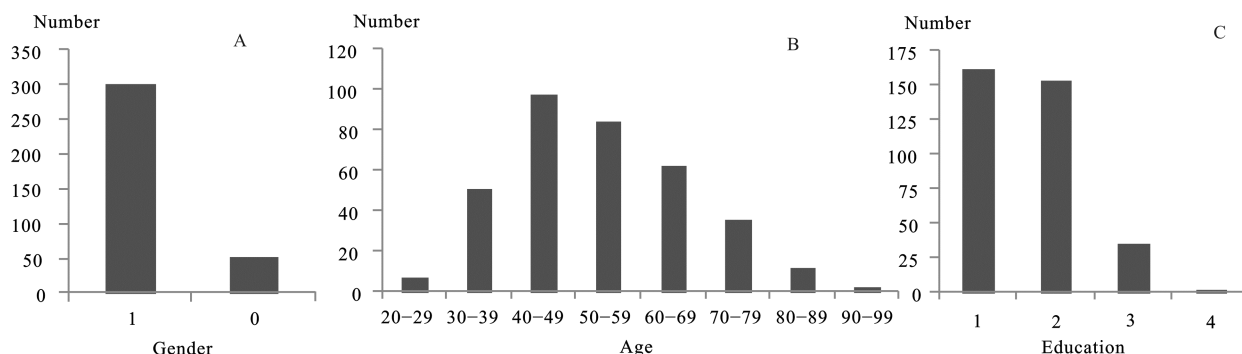


Fig. 4 Status of the household head. A: 1 means gender of household head is male and 0 means female ; B: the horizontal axis number indicates age of the household head between 20 to 29 years old, 30 to 39 years old, ..., 90 to 99 years old; C: 0 to 4 mean respectively that the education level of the household head is illiterate, elementary school, junior high school or high school and above

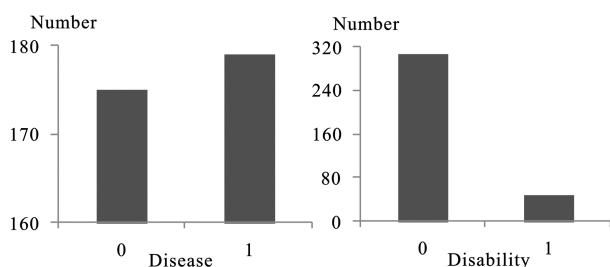


Fig. 5 Health status. 0 means there are no patients with major illnesses or the disabled and 1 means there are patients with major illnesses or the disabled in a household in the two figures

in-depth implementation of the strategy of poverty alleviation impelled by the State Council of China, the local government of Hainan Province and Lingao County launched a more active reform of medical and health on the poor households. These policies that award the poor households prior medical treatment, high proportion of reimbursement of medical expenses and minimum living security have been firmly implemented, which improved the condition of medical treatment and eased the economic pressure of the poor households greatly.

4.2.5 Traffic accessibility

Traffic accessibility of Lingao County was calculated according to the above method and was shown as Fig. 6. It can be found that the time cost of the household to the center of the administrative village, town and county town is 1.3–17.4 min, 6.3–31.1 min and 10.7–69.7 min, respectively, and the average time cost of which is 5.8 min, 18.9 min and 27.6 min, respectively. In theory, convenient traffic conditions are propitious to the export of agricultural products and services and the import of such elements as advanced management modes, market economic ideas and production tools, and should have significant influence on the development of regional

economy and the improvement of livelihood of the residents. However, the impact of the traffic accessibility on poverty is insignificant in this study, which is not consistent with the prejudgment. The causes lie in that the gap of traffic accessibility among the households in the same natural village is small due to the spatial agglomeration distribution of the households and the conditions of topography, geomorphology and traffic, though there exists big gap of traffic accessibility among the households in different natural village to the center of the administrative village, town and county town. And the economic activity and income of the households have not been impacted significantly for this gap. In other words, the construction of transport infrastructure has obvious effectiveness to the overall economic growth of the poverty-stricken villages, but at the micro level, the benefits that the poor households got from the construction of transport infrastructure are relatively limited, these households whose income exceeds the medium level of the poverty-stricken villages are usually the biggest beneficiaries. This consultation is in accordance with the viewpoint in the mid-term assessment report of the 'China Rural Poverty Alleviation and Development Program (2001–2010)' and confirms the research findings of Khandker and Koolwal (2010).

5 Discussion and Conclusions

5.1 Discussion

As one of the most hotspot and focal issue in the field of sustainable development, rural poverty and poverty reduce has attracted worldwide attention. The existing literatures on rural poverty and poverty reduction focalized on the theoretical interpretation of the concepts,

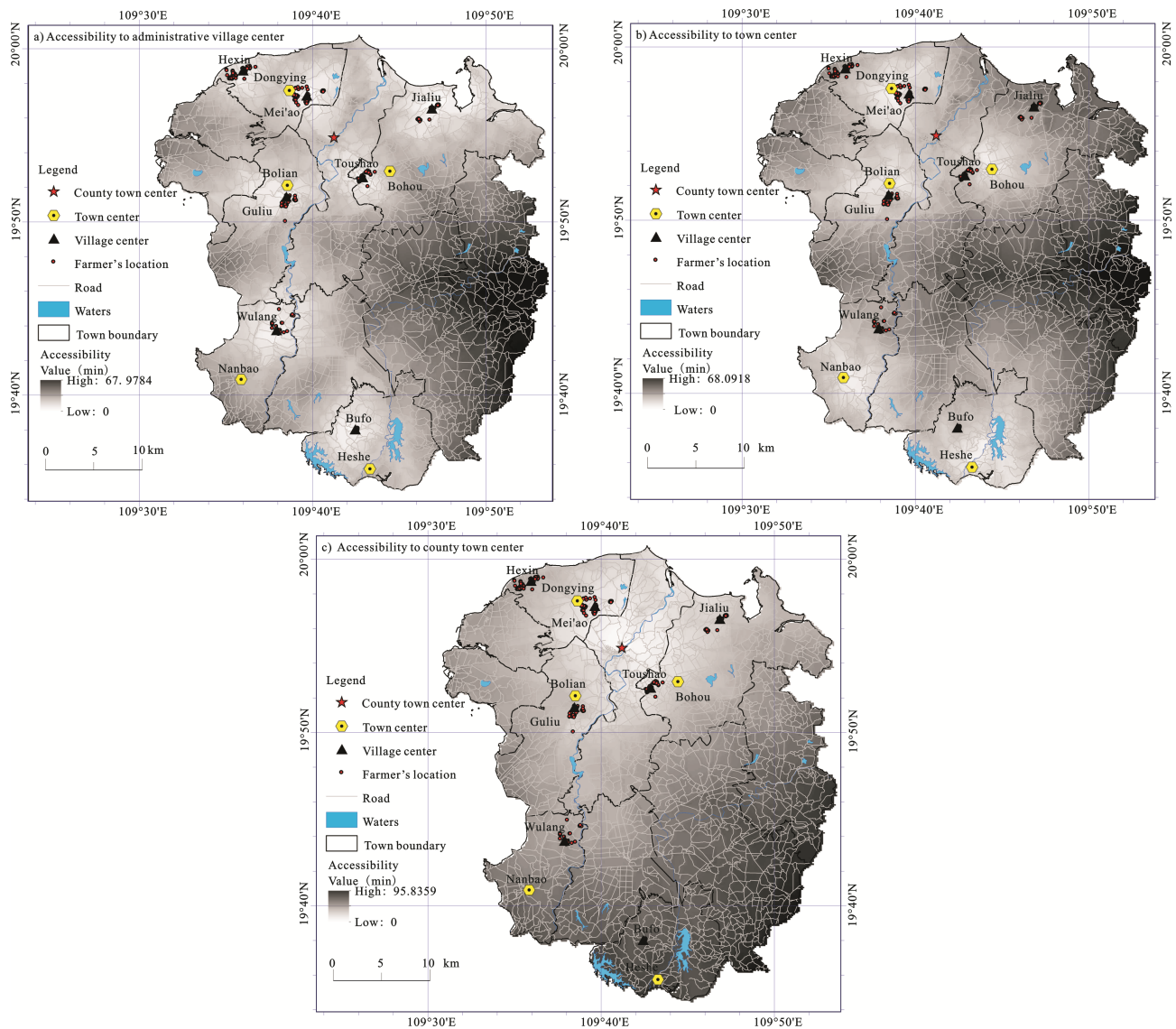


Fig. 6 Traffic accessibility of Lingao County

connotations, criterions and influencing factors of poverty and practical discussion of the policies, approaches and effectiveness of poverty reduction at the global and regional scale, but were shortage of the in-depth discussion and quantitative analysis on the influencing factors and mechanism of poverty at the local level. The traditional measurement model based on OLS ignores the spatial association and correlation of neighborhood units, and lacks sufficient explanatory power in expressing the spatial correlation of the influencing factors on poverty. Therefore, this paper, using the spatial regression model, examined the spatial autocorrelation of poverty and its influencing factors quantitatively, which has a better effect in illuminating the multidimensional influencing factors of poverty. For example, the disease

factor is significant in the OLS model, but it is not significant in the SLM, indicating the necessity of incorporating the geospatial effect when modeling the influencing factors of poverty based on the microscopic household survey data. In addition, the statistical values of R^2 , Log likelihood, AIC and SC of the SLM achieved significantly improvement, which means the simulation results are more reliable in illuminating the influencing factors of poverty.

The simulated results of the SLM objectively reflect the influence of household structure, income structure, health status, education and medical care, transportation infrastructure on rural poverty in Lingao County. Such variables as minor children, farming peasants, migrant workers and wage-equivalent income have significant

impacts on rural poverty, indicating that local governments should help the household eliminating the backward ideas of fertility of 'multi-child blessing' and 'subordinate generation' under the premise of the educational support policies, and formulate effective poverty reduction policies in terms of farmer vocational skills training, agricultural specialization and large-scale management, non-agricultural development and rural surplus labor transfer. The educational level of the head of household has insignificant effect on the rural poverty in Lingao County, but the worse cultural quality of the population is the deep-seated factor of rural poverty and backwardness. Although the local government implemented the educational and cultural poverty alleviation projects of "Rain Plan" that covers from the pre-school education to higher education and "TV night school technical training" for poor households, but it did not fundamentally change the situation of low quality of rural labor. Backward cultural and educational concepts and production concepts not only restrict the flow of labor and the choice of employment space, but also make these educational and cultural poverty alleviation projects play an insignificant role in the practice of poverty reduction in the short term. It can be found from the survey that the poor households generally believe that education is important to improve the situation of family poverty, and they have the willingness to let their children receive better education and look forward to the stable educational support of the local government. The impact of traffic accessibility on the rural poverty in Lingao County is not significant. This conclusion has its applicability to the micro-level analysis of households in extreme poverty areas, especially in the northern rural areas where the topography is not bad enough to cause travel difficulties in Lingao County. The construction of transportation infrastructure plays a very limited role in greatly improving the economic and living standards of the poor households in a short term, but it has long-term significance to change the backwardness of the poverty-stricken areas at the village and the town level. The poor households can benefit from the trickle-down effect of the economic growth of the villages and towns, and gradually change the poverty situation. The survey found that the poor households generally believe that the construction of village roads improved the rural traffic conditions and enhanced their sense of belonging, happiness, and confidence of poverty alleviation.

As a typical poverty-stricken area in Hainan Province, the nature of poverty is still regional and holistic in Lingao County. There are prominent issues of the unreasonable distribution of rural production resources and operational income and part-time worker in charge of income structure, less non-agricultural economic activities, low degree of agricultural diversification and scale, restricting the rapid improvement of the economy and living standards of the poor households. However, the pattern and process of poverty in the study area are affected by the combination of common factors and regional factors. The mechanisms by which all factors affect the pattern and process of poverty are difficult to explain through simple statistical models in our study. Considering the interrelationship between various factors, the establishment of nonlinear complex system structure model is a useful way to explain the mechanism of various factors on poverty. As the research deepens, it will be one of the important issues to be explored in the future.

Under the macro background of the national and local governments to vigorously implement the targeted poverty alleviation, it is a major issue that needs the local governments to pay great importance and study deeply on how to formulate the reasonable policies of targeted poverty reduction relying on the resources, location and environmental conditions of poverty-stricken areas. On the one hand, we should improve the policy guarantee system and implement such policies of educational poverty alleviation as the government providing the fully financial aid for 'clothing, food, accommodation, transportation, tuition and fees' of students in the compulsory education stage, setting 'Education Poverty Alleviation Scholarship' and implementing the 'Rain Plan', and implement such policies of health poverty alleviation as medical assistance of the government responsible, the medical insurance of new rural cooperative paid by the government fully, so as to effectively reduce the pressure on education and medical expenses for poor households. On the other hand, we should give full consideration to the situation of the labor force, the living and the production, and the cause of poverty of poor households, formulate measures to meet the needs and wishes of farmers according to local conditions, and focus on industrial help, the development of the characteristics of leading industries and industrial poverty reduction policies targeted the village and the household,

to promote the development of industry characteristics, cultivate multi-level and large-scale professional cooperatives for farmers, leading enterprises and distinctive agricultural base. In addition, we should establish multiple joint help mechanism of the government, enterprises, social organizations and poor groups, and run a multi-operational mechanism of government support and supervision for leading enterprises and agricultural specialization organizations and that of government guidance and assistance to poor farmers, so that cultivate and form a multi-faceted participatory interaction mode involving leading enterprises, poor households and agricultural specialization organizations. Finally, we should increase the vocational education for the practical skills and labor export of poor households to improve the overall quality and employability of farmers, and adopt a diversified training mode to enhance the farmers' skills to move out of poverty and confidence to get rich, to improve the effectiveness of targeted poverty alleviation work in Lingao County.

5.2 Conclusions

Based on the survey data of 354 poverty households and the in-depth investigation and interviews of the poverty-stricken villages in the sampled areas, this paper analyzed the characteristics of rural poverty in Lingao County, a typical poverty-stricken area in Hainan. Through the comparison analysis of regression models such as OLS, SLM and SEM, the main influencing factors of rural poverty in the county were discussed using the SLM model. The main conclusions are as follows:

Firstly, the nature of rural poverty in Lingao County is regional and holistic, and the poor households are mainly distributed in the northern part of the county with obvious characteristics of spatial clustering. The poor households have a relatively high Engel coefficient, and the food, tobacco and alcohol are the main expenditure. Most of the poor households have low educational heads, abundant but poor-quality labor force, larger size of household, minor children and patients or disabled persons, and the proportion of poor households is high due to the education, disease and disability. Some of the poor households have not enough willingness and ability of self-improvement influenced by the local culture and traditional lifestyle.

Secondly, rural poverty is influenced by such factors as household structure, income structure, health status,

education and medical care, and transportation infrastructure. The results of the SLM showed that the variables that reflect the household structure and income structure have significant impact on rural poverty in Lingao County. Among these 15 variables, the number of both minor children and farming peasants has significant negative impact on poverty, while the number of migrant workers and the proportion of wage-equivalent income have significant positive impact on poverty. However, the gender, age and educational level of the household head, as well as the health status and traffic accessibility of the household, have insignificant impact on rural poverty in Lingao County.

This study can be of reference for the formulation of poverty reduction policies in areas of Lingao County and those areas that are not subject to natural conditions and resource conditions and have a relatively abundant labor force but are greatly affected by local traditional culture.

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