



The geography of poverty: Review and research prospects

Yang Zhou^{a,b,c}, Yansui Liu^{a,b,c,*}

^a Institute of Geographic Sciences and Natural Resources Research, Center for Assessment and Research on Targeted Poverty Alleviation, Chinese Academy of Sciences, Beijing, 100101, China

^b Faculty of Geographical Science, Beijing Normal University, Beijing, 100875, China

^c University of Chinese Academy of Sciences, Beijing, 100049, China

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ABSTRACT

Geography of poverty (GOP) or poverty geography is a branch of human geography, which studies the geographical patterns, distribution characteristics, areal types and evolution mechanism of poverty and the relationship with geographical environment as well as antipoverty measures. Based on the systematical analysis on the significance of GOP research, this study firstly put forward the impoverished areal system (IAS), and then elaborated the main contents, research progresses and existing problems in GOP research, and finally proposed the possible key areas in the future. Results show that the IAS is an open system with structure and function and has its life-cycle law, which is composed of natural endowments, location conditions, human capital and geographical capital within a certain geographical area. The subsystem of human, land and industry is the core of the IAS. Poverty geography studies both regional (place) poverty and individual (people) poverty. Regional poverty is an external manifestation of the coupling maladjustment of human, land and industry elements in a particular area. There are 5W + H (What, Where, Why, When, Who and How) models in GOP research. Key areas of future GOP research include: 1) IAS's life cycle evolution law; 2) regional multidimensional poverty measurement; 3) geographical identification of poverty and its areal type; 4) dynamic simulation of impoverished and its mechanism; 5) poverty mapping; 6) antipoverty measure; and 7) poverty reduction effectiveness evaluation. Facing the UN's goal of eradicating poverty by 2030, poverty geography research in the new period should focus on the complexity, spatial heterogeneity and mechanism of poverty, and designs anti-poverty paths and models suitable for different countries. To adapt to the trend of globalization and informationization, poverty geographers should make use of modern technologies such as data platform, cloud computing, remote sensing and artificial intelligence to focus on the spatio-temporal pattern of poverty and its driving mechanism as well as antipoverty path, and to solve the global poverty problem and promote the internationalization, basicification and engineering of geography.

1. Introduction

Poverty has always been a major problem perplexing the progress of human society. The United Nations 2030 Agenda for Sustainable Development has set 17 sustainable development goals, among which the first one is to end poverty in all its forms (Griggs et al., 2013). Poverty research has a long history, but there is still a lack of consistent definition of poverty. Different disciplines have their own understanding, cognition and concern on poverty (Zhou et al., 2018a). Poverty was initially understood as an economic phenomenon, which refers to the situation that individuals or families' income cannot reach the standard

of socially acceptable living standards. As early as 1981, the World Bank defined poverty as the lack of opportunity of part of the group without ability to gain the socially recognized and generally enjoyed diet, living conditions and to participate in activity (World Bank, 1981). Amartya Sen (Sen, 1982, 1985) put forward the concept of capability and entitlement poverty, and pointed out that poverty is not only low income, but also a deprivation of basic capacity. Subsequently, the concept of capability poverty evolves into the human development index (UNDP, 1990), human poverty index (UNDP, 1997) and multidimensional poverty index (UNDP, 2010). With the in-depth research, poverty has been acknowledged to include economic shortages, social exclusions,

* Corresponding author. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A Datun Road, Chaoyang District, Beijing, 100101, China.

E-mail addresses: zhouyang@igsrr.ac.cn (Y. Zhou), liuys@igsrr.ac.cn (Y. Liu).

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lack of opportunity or public services, and vulnerability or exposure to risk of those deficits (Bourguignon and Chakravarty, 2003; UNDP, 2010; Liu and Xu, 2016).

Classification of poverty has different standards and methods. In general, poverty can be divided into absolute and relative poverty (Foster, 1998; Chen and Ravallion, 2007), chronic (persistent) and transient poverty (Hulme and Shepherd, 2003; Ward, 2016), regional (place) and individual (people) poverty (Powell et al., 2001; Park et al., 2002; Bourguignon and Chakravarty, 2003; Milbourne, 2004, 2010; Liu et al., 2017) and urban and rural poverty (Amato and Zuo, 1992; Du et al., 2005). Regional poverty is a chronic or persistent poverty, while individual poverty is transient (Liu et al., 2017). Individual poverty is closely related to regional poverty, and they are mutual influenced and interacted. Regional poverty usually leads to a lack of endogenous impetus for individual development in a region, in turn, individual poverty results in the slow socio-economic development and the lack of infrastructure and public service guarantee of the whole region, accumulating as regional poverty (Liu and Xu, 2016; Liu et al., 2017; Ding and Leng, 2018; Zhou et al., 2018b, 2019). Both individual poverty and regional poverty are affected by human, social, financial, physical, natural and livelihood capital as well as its synthetic geographical capital, and these influencing-poverty factors vary across different time scales and geographical regions (Liu and Xu, 2016; Ding and Leng, 2018). Poverty reduction should not only stimulate the endogenous motivation of the poor, but also improve the production and living conditions in poor areas (Liu and Xu, 2016). The solution of regional poverty is the basis and prerequisite of eliminating individual poverty (Kolenikov and Shorrocks, 2005; Luo and Li, 2014; Liu and Xu, 2016; Ding and Leng, 2018). The humanities and social sciences tend to focus on the shortage of stratum elements (people poverty) and did not give sufficient attention to regional poverty. The formation mechanism, geographical distribution and spatial pattern of regional poverty, and its relationship with geographical environment provide opportunities for geography to give full play to its spatial analysis and systematic advantages in the study of poverty (Ding and Leng, 2018).

Geography mainly focuses on the spatial distribution, evolution mechanism and regional characteristics of geographical elements of the land surface (Fu, 2014). Human-land relationship is the core of geography research (Wu, 1991; Fu, 2017). From the perspective of human-land relationship areal system, regional poverty is an external manifestation of man-land relation incompatibility in specific areas (Liu et al., 2016, 2017; Ding and Leng, 2018; Zhou et al., 2018a, 2019). The academia has been recognized the importance of the study of the spatial dynamics of poverty from the perspective of geography for a long time (Green, 1994; Kodras, 1997). A large number of models and methods have been used to identify the geographical distribution, differentiation mechanism and leading factors of poverty, such as spatial analysis (Liu et al., 2017; Zhou and Xiong, 2018), geographically weighted regression (Okwi et al., 2007; Xu et al., 2018), big data (Blumenstock et al., 2015), multidimensional poverty index (Liu and Xu, 2016; Wang and Chen, 2017; Wang et al., 2018; Santos and Villatoro, 2018; Alkire and Fang, 2018), human cartographic approach (Ballas et al., 2017), BP neural network model (Zhou et al., 2018a), computable general-equilibrium (CGE) model (Savard, 2005) and econometric model (Jalan and Ravallion, 2002). Among them, multidimensional poverty index is the most commonly used method for identifying poverty-stricken areas, which has been used in global or regional poverty research (Deutsch and Silber, 2005; Alkire and Foster, 2011; Alkire and Santos, 2014; Alkire and Seth, 2015; Bader et al., 2016; Alkire et al., 2017; Santos and Villatoro, 2018; Guo et al., 2018). However, compared with economics and sociology, the systematic study of poverty from the perspective of geography is still inadequate and most of them are mainly empirical analysis (Ding and Feng, 2018; Luo and Li, 2014). In view of the systematic, regional and spatial analysis advantages of geography, it is urgent to study the poverty problem from the perspective of geography to better serve the sustainable development goals by 2030. Thus, the main aim of this study

was to stress the significance of poverty from the perspective of geography, explore the evolution process of geography of poverty (GOP), review its research progress and existing problems, and propose the main directions and key issues in the future. These findings will help to enrich GOP's theory, expand its research fields and promote GOP's frontier exploration.

2. Literature review

2.1. Theoretical foundation of GOP

Poverty has multidimensional and spatial attributes. The multifaceted nature of poverty is further compounded by its spatial distribution (Gauci, 2005), which has sparked significant interest in poverty geography over the past decades (Gray and Moseley, 2005; Dasgupta et al., 2005; Barbier, 2010; Bird et al., 2010). The most famous theory is environmental determinism of poverty from Jeffrey Sachs, who asserts that geographical environment determines the economic outcomes of nations. Many poor countries are poor because they are landlocked and situated in high mountain ranges, like Switzerland (Sachs et al., 2001; Sachs, 2008). In fact, as early as 1950s, space economics noticed the phenomenon of spatial poverty earlier, which studies the economic activities and spatial layout of various productive factors from the perspective of space (Harris, 1954). In 1990s, the new economic geographers, represented by Paul Krugman, explored the spatial dimensions of economic activities and began to focus the poverty-environment nexus (Krugman and Venables, 1995; Krugman, 1991, 1995; Fujita et al., 1999), and then the spatial poverty theory begin to take shape. The emergence of spatial poverty theory has pushed the research of poverty geography to a new height (Danziger and Gottschalk, 1987; Bird et al., 2002, 2010; Bird and Shepherd, 2003; Crandall and Weber, 2004; Minot et al., 2006; Rupasingha and Goetz, 2007). Since the mid-1990s, the World Bank has begun to focus on the spatial distribution and differentiation of global poverty and found that geographical capital synthesized by many geographical elements affects farmers' income (Jalan and Ravallion, 1998; Deichmann, 1999). Geographical capital is a collection of material, social and human capital formed by spatial geographical location and natural environment conditions (Jalan and Ravallion, 1998; Ravallion and Wodon, 1999; Deichmann, 1999; Bird and Shepherd, 2003; Liu et al., 2014). Spatial poverty theory links poverty with spatial geographical factors, and it emphasizes the important role of spatial geographical location in the formation and even maintenance of poverty. The verification of spatial poverty traps (SPTs) has greatly promoted the GOP research. On the other hand, with the deepening of research, poverty is gradually recognized as multidimensional, and it is difficult to reveal the essence of poverty by single factor. Sen (1982, 1985) defined poverty from the perspective of capability, forming the famous capability poverty theory. The theories of capability and spatial poverty laid the foundation for the development of later multidimensional poverty theory (Tsui, 2002; Deutsch and Silber, 2005; Alkire and Foster, 2011). Recently, Liu et al. (2017) put forward the island effect theory of the evolution of poverty, pointing out that with the promotion of poverty reduction efforts and the precision of the objectives, the poor will gradually gather to form an island group.

2.2. Spatial poverty traps

Spatial agglomeration of poverty areas or impoverished population caused by the lack of geographical capital is called SPTs (Bird et al., 2010; Kraay and McKenzie, 2014). From the perspective of geography, the academic circles have discussed deeply the SPTs' definition and tested its existence. For example, Jalan and Ravallion (1997, 2002) used a micro model to test for the SPTs' existence in China. Daimon (2001) argued that the SPTs is a persistent state of poverty caused by location characteristics or excessive migration costs. Bird and Shepherd (2003) pointed out that the SPTs occurs in the areas where geographical capital

is low and poverty level is high. The SPTs is usually distributed in remote geographical location, fragile ecological environment, poor infrastructure and public service supply, and politically disadvantaged areas (CPRC, 2004). Subsequently, the existence of the SPTs was verified in many countries around the world, such as Zimbabwe (Bird and Shepherd, 2003), Vietnam (Minot et al., 2003), Indonesia (Daimon, 2001), Africa (Christiaensen et al., 2003), England (Meen, 2009), Kenya (Burke and Jayne, 2008), Pseudo (Azevedo and Robles, 2010), Russia (Guriev and Vakulenko, 2015), Mexico (Albertus et al., 2016) and China (Jalan and Ravallion, 2002; Wu and He, 2018).

2.3. Geographical environment and regional impoverishment

Geographical elements affecting poverty involve location, resource endowment, ecological environment, public service, regional policy and culture (Bigman and Fofack, 2000; Do and Iyer, 2010; Luo and Li, 2014). Previous studies have shown that there is a “downward spiral” between regional impoverishment and environmental degradation (Scherr, 2000; Cavendish, 2000; Gray and Moseley, 2005; Dasgupta et al., 2005; Lufumpa, 2005; Cao et al., 2009; Barbier, 2010; Casillas and Kammen, 2010; Watmough et al., 2016). Remote geographical location is usually regarded as the main cause of high incidence in semi-arid region of Zimbabwe (Bird and Shepherd, 2003). Even in developed countries such as the United States and Britain, rural impoverishment and geographical location are closely related, and poverty incidence rises with the distance from metropolitan areas (Partridge and Rickman, 2008). In China, ecologically fragile areas are highly overlapped with poor areas (Liu et al., 2017). According to our statistics, in 2014, more than 40% of China’s rural poor population were distributed in ecologically fragile areas, of which 19% are in rocky desertification areas, 16% in soil erosion areas, 4% in land desertification areas and 0.3% in freeze-thaw erosion areas (Liu et al., 2015, 2017).

Furthermore, topographic condition, slope, surface fragmentation, distance/travel time to public resources or services, elevation and land-use type are also closely related to poverty (Bigman and Fofack, 2000; Henninger and Snel, 2002; Okwi et al., 2007; Cheng et al., 2018; Zhou and Xiong, 2018; Ma et al., 2018). Complex topography has a positive driving effect on the spatial distribution of poverty-stricken countries in China (Zhou and Xiong, 2018). Natural conditions play a scale-independent role to poverty incidence (Cheng et al., 2018). Soil erosion can affect the quality of agricultural land, forming a vicious circle of ecological damage, soil erosion, farmland decrease, pauperization, steep slope reclamation and ecological degradation (Scherr, 2000). Natural disasters and climate change are also regarded as driving forces for rural impoverishment (Hertel and Rosch, 2010; Gentle and Maraseni, 2012; Casillas and Kammen, 2010; Hallegatte et al., 2017; Hallegatte, 2012). Natural disasters perpetuate poverty and make it harder for poor people to escape poverty (Rozenberg and Hallegatte, 2016; Datt and Hoogeveen, 2003; Rodriguez-Oreggia et al., 2013; Hallegatte et al., 2017; Akter and Mallick, 2013). Globally, natural disasters forces around 26 million people falling into extreme poverty each year (Hallegatte et al., 2017; Rozenberg and Hallegatte, 2016). By 2030, about 325 million extremely poor people are expected to live in the 49 most hazard-prone countries around the world, the majority in South Asia and sub-Saharan Africa (Shepherd et al., 2013).

2.4. Poverty measurement and mapping

Poverty estimation/measurement and its geographical identification are the basis of poverty map-making. Poverty identification includes the identification of poor areas and impoverished population. A large number of models/methods have been developed/used to estimate the poverty indicators for small areas, such as spatial regression (Okwi et al., 2007), unit level model (Elbers et al., 2003), empirical best method (Molina and Rao, 2010), temporal and spatiotemporal area level models (Esteban et al., 2012), hierarchical Bayes estimation (Molina et al.,

2015), unit level logit mixed model (Hobza and Morales, 2016), M-quantile model (Tzavidis et al., 2008; Chambers et al., 2016; Marchetti et al., 2018), system dynamics model (Cheng et al., 2018), twofold nested error regression model (Marhuenda et al., 2017) and custom-built model (Edward and Sumner, 2014). Many income-based poverty indicators are complex non-linear functions of the incomes. Regional poverty has also multidimensional characteristics as with individual poverty. Poverty dimensions are often correlated and mutually reinforced (Alkire and Foster, 2011; Alkire and Santos, 2014). Usually, it is difficult to use mathematical model to reveal multidimensional poverty characteristics of a region. The measurement of regional poverty needs to establish an index system and based-mechanism model of comprehensive poverty (Ding and Leng, 2018). The construction of the index system is usually influenced by the cognitive level, research scale and data availability (Edward and Sumner, 2014; Liu and Xu, 2016; Wang and Chen, 2017; Ma et al., 2018).

Poverty map-making is the spatial representation and analysis of human wellbeing indicators. It can reveal the geographical pattern of poverty and its spatial heterogeneity, which helps guide priority-setting and target-alleviation interventions as well as the allocation of resources (Erenstein et al., 2010). However, major challenges of poverty mapping remain that both measuring poverty and its mapping are data intensive (Erenstein et al., 2010). Using accumulative census data often leads to a biased estimation (Bigman and Fofack, 2000; Fofack, 2000; Minot and Baulch, 2005). More recently, disparate data sources (big data), including night light, satellite image and mobile phone metadata have been used to predict or map poverty (Blumenstock et al., 2015; Jean et al., 2016; Pokhriyal and Jacques, 2017; Steele et al., 2017). The scale of research has evolved from national to subnational, district and even to farmer’s level, such as subnational scale in Zambia (de la Fuente et al., 2015), district-level in Poland (Marchetti et al., 2018), Vietnam (Minot and Baulch, 2005) and India (Erenstein et al., 2010), and farmers’ level in Africa (Blumenstock et al., 2015; Jean et al., 2016). Combined nighttime maps with high-resolution daytime satellite image can accurately track and target the object of poverty (Blumenstock et al., 2015; Jean et al., 2016).

2.5. Poverty targeting

Geographical targeting of poverty is a viable way to allocate resources for poverty alleviation (Bigman and Fofack, 2000; Okwi et al., 2007), especially for smaller geographic areas (Baker and Grosh, 1994; Bigman et al., 2000; Schady and Norbert, 2002; Ravallion and Wodon, 1999; Agostini and Brown, 2011). Geographical targeting involves in the regions and individuals. Theoretically, the best way to help the poor is to transfer the limited funds (resources) to the poor, but it is difficult for most countries to implement due to high administrative and data collect cost (Bigman and Fofack, 2000). China has achieved the aim of targeting the poor households (Liu et al., 2017, 2018; Zhou et al., 2018a). Given that the poor is usually concentrated in a specific area, regional targeting is considered an effective way to guide the flow of poverty alleviation funds (Schady and Norbert, 2002; Crandall and Weber, 2004). The advantage of geographical targeting is that it is unconstrained by information, easy supervision and management, little influence on household behavior, and easy to combine with other antipoverty measures (Bigman and Fofack, 2000). Targeting smaller administrative units such as districts or villages helps improve the effectiveness of poverty reduction (Ravallion and Wodon, 1999; Bigman and Srinivasan, 2002; Park and Wang, 2010; Elbers et al., 2007). Combined big data fusion and multidisciplinary approach integration, poverty geography needs to target the priority regions and individuals for poverty alleviation.

3. Summary

Poverty has long been a concern of academia. Different disciplines have done a lot of research on poverty from different perspectives,

which provides a beneficial reference for the formulation of poverty reduction policies. Although the important role of geographical environment in poverty has been recognized, systematic research on poverty geography is still insufficient. Previous studies have paid more attention to the spatial identification of poverty-stricken areas or poor population, and the underlying mechanism of poverty is poorly understood. In addition, there was a lack of theoretical research on poverty from geography and most existent studies were based on the spatial poverty and multidimensional poverty theories. More importantly, there was lack of overall consideration of regional (place) poverty and individual (people) poverty studies (Powell et al., 2001; Milbourne, 2004, 2010). Or it can be argued that geographical factors are only the background of most poverty studies. Geography pays close attention to the man-land relationship, which has comprehensive and regional characteristics. The problem of poverty also has regional and systematic characteristics. Studying poverty from geography can take poverty into consideration in the system and reveal the mechanism of poverty at different scales.

4. Impoverished areal system and geography of poverty

Poverty is a complicated system problem. Following the definition of rural areal system (Liu et al., 2009; Long, 2013; Li et al., 2015; Tu et al., 2015; Long et al., 2016; Tu and Long, 2017), the impoverished areal system (IAS) can be defined as an open system with structure and function, which is composed of natural endowments, location conditions, economic foundation, human capital and geographical capital within a certain geographical area. The subsystems of human, land, industry is the core of the system, which affects by geographical locations, natural endowments, eco-environment and socioeconomic development level, etc. With the advancement of globalization, urbanization, industrialization and informatization, information transmission, energy flow and material circulation occur between the exterior and the interior of the system. If the exchange of material circulation, energy flow and information transmission in IAS is not smooth, regional poverty will appear (Fig. 1). Man is the main body of the system, land provides space carrier for human survival and development, and industry serves as the intermediate link between man and land (Zhou et al., 2018a, 2019; Guo et al., 2018). With the growth of population, if cultivated land

in a region cannot meet the needs of human social development, human beings are forced to destroy forests, which aggravates land degradation, and the fragile environment in turn restricts the development of human society, thus forming a vicious circle of poverty, i.e., population growth, environmental degradation and poverty. In the long run, ecological degradation, lagging infrastructure and public services, and inadequate socio-economic development will inevitably occur in similar areas. Thus, regional poverty can be defined as a state of poor infrastructure and public services and backward socioeconomic development in specific areas due to various adverse factors such as lack of natural endowment, fragile ecological environment, frequent natural disasters, poor local conditions, historical background and policy (Bigman and Fofack, 2000; Zhou et al., 2018a, 2019). Regional poverty is the result of pauperization or impoverishment in a specific region. It is an external manifestation of the coupling maladjustment of human, land and industry in specific areas (Liu et al., 2017; Zhou et al., 2018a, 2019; Ding and Leng, 2018). The premise and key to alleviate regional poverty is to identify the main poverty factors and break the poverty trap.

The IAS is a complex giant system, and its boundary is not invariable, but changes over time. For example, at the beginning of founding of new China, the whole country was in a state of total poverty due to successive wars, perennial famine and frequent natural disasters (Liu et al., 2018). With the increase of anti-poverty efforts, the rural poor in China gradually gathered towards the deep-stone mountain area and environmentally fragile areas in the early twenty-first century (Liu et al., 2018). Since the implementation of the targeted poverty alleviation policy in 2013, China’s regional overall poverty problems have been effectively relieved (Liu et al., 2017; Zhou et al., 2018b). However, the remaining rural poor population is gradually gathering in deep poverty areas. By the end of 2017, there were still 229 deep poverty counties with more than 18% of the incidence of poverty, 29,800 deep poverty villages with more than 20% of the incidence of poverty and 30.46 million poor population in China (Xinhua net, 2018). There is no doubt that with the further promotion of poverty alleviation measures, China’s rural poor regional system will evolve into a series of isolated island groups (Liu et al., 2017).

Because of the multidimensional and complex nature of poverty, it is an inevitable trend for human society to study the geographical pattern,

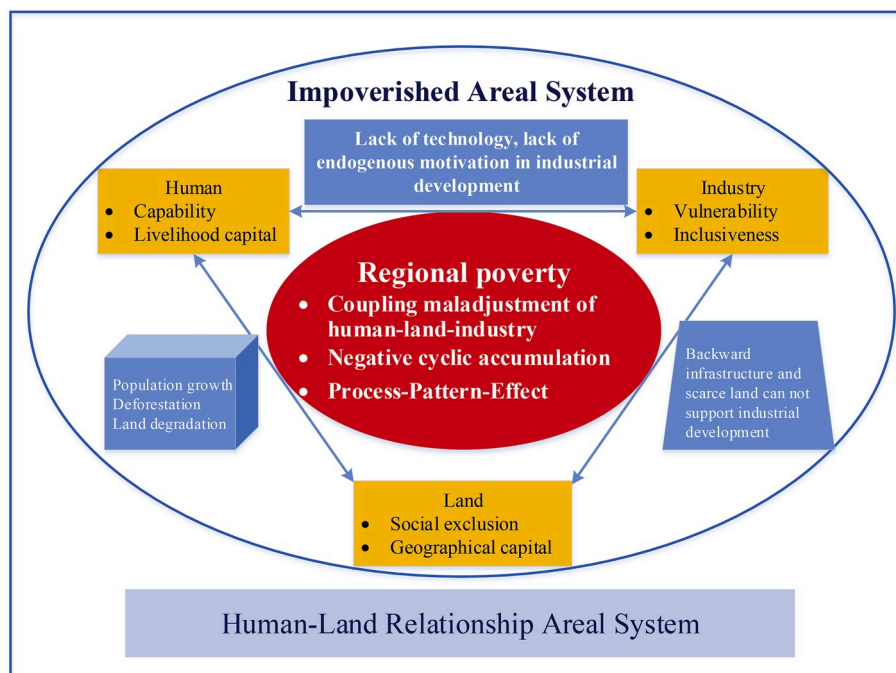


Fig. 1. Formation mechanism of regional pauperization.

mechanism and path of poverty reduction from the perspective of geography. Poverty geography is a branch of human geography, which studies the formation mechanism, distribution characteristics, areal types and evolution mechanism of regional impoverishment, and its relationship with geographical environment and antipoverty measures. The man-land relationship areal system is the core of human geography research. The IAS is an important part of the man-land relationship areal system. Poverty geography studies the IAS system, which focuses on the structure, function of the system of the system and interaction mechanism of among the elements in the system as well as its sustainability.

5. The 5W + H models of GOP

The GOP focuses on the 5W + H (what, where, why, who, when and how) issues (Fig. 2). First, what is poverty? It is necessary to define poverty from the perspective of man-land relationship in geography. As mentioned above, poverty can be regarded as an external manifestation of the coupling maladjustment of human, land and industry elements in specific human-land areal system. With this definition, poverty geography needs to study the connotation, types, criteria and thresholds of poverty.

Second, where are the poverty-stricken areas or poor people located? Poverty geography needs to portray the geographical pattern of poverty, divide its areal types and reveal its spatial heterogeneity. Previous studies have shown that the poverty-stricken areas are usually concentrated in the eco-environment vulnerable areas and disaster-prone areas (Hallegatte, 2012; Hallegatte et al., 2017). Globally, the extreme poverty population mainly concentrated in middle- and low-income countries over the past decades (Shepherd et al., 2013). However, global distribution of the extreme poverty population has experienced a shift from middle-income countries (MICs) to low-income countries (LICs). In 1981, 90.77% of the world's poor people lived in MICs and 8.87% in LICs, while in 1990, 87.93% in MICs and 11.68% in LICs, and in 2013, 63.25% in MICs and 35.71% in LICs, mainly in Sub-Saharan Africa and South Asia (Fig. 3; World Bank, 2018). This indicates that the mass of the poor did not live in the world's poorest countries (Kanbur and Sumner, 2012; Sumner, 2012), which provides an opportunity for geographers to analyze the distribution of the global poor population and its spatial differentiation. Multidimensional poverty identification also showed that 72% multidimensional poverty people live in middle-income countries, of which 48% live in South Asia and 36% in Sub-Saharan Africa (Alkire and Robles, 2017). Targeting extreme poor people in poverty-stricken areas is the basis and premise for improving poverty reduction effectiveness (Park et al., 2002). The GOP research

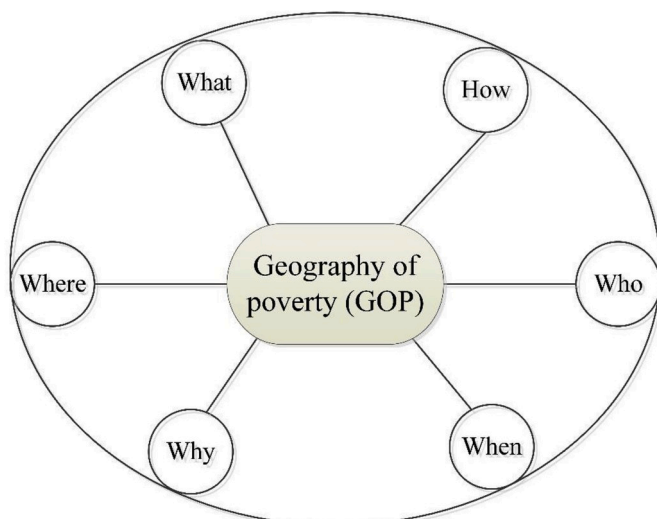


Fig. 2. The 5W's and H contents of the research on geography of poverty.

needs to aim at poor areas and their extreme poor people scientifically.

Third, why does poverty happen? Or why does poverty persist? It needs to explore the root cause of poverty, identify its main contributors and reveal the dynamic mechanism behind regional/individual poverty. Both regional and individual poverty have multidimensional attributes, which are affected by natural and human factors. Policy intervention needs to break through the “vicious cycle of poverty”. Thus, it is critical to understand the driving forces of poverty. Poverty geography studies need to identify the key variables, mechanisms and processes of regional/individual impoverishment, and to explore the relationship between pauperization and geographical environment (or geographical capital) and measure the contribution rate of elements to poverty.

Fourth, when is the most obvious poverty? Usually, poverty is the most prominent when regional human-land relation is serious unbalanced and no effective policy intervention is available. Usually, sudden natural disasters and other shocks aggravate the level of poverty in a region or family, and critical diseases and misfortune immediately force a family into extreme poverty. Besides, poverty geography also cares about who is the poorest. In fact, poverty is a relative concept. Because of the different poverty standards, the extreme poverty population in one country or region is not necessarily the real poor in another country or region. The identification of relatively poor population in different regions is the basis for the implementation of differential anti-poverty measures. Mapping poverty and its correlates could provide a better analytical instrument in discerning why there continues to be persistent poverty in certain areas (Gauci, 2005).

Finally, how to alleviate poverty? Poverty geography research must be oriented-goal of poverty alleviation, which serves national or regional poverty reduction making-decisions. The effective formulation of anti-poverty measures should be based on the research on the geographical identification, areal type classification and mechanism analysis of regional impoverishment. It is also necessary to consider the difficulty of reducing poverty and to determine the timetable and priority areas of poverty reduction. Besides, poverty geographers also need to study and summarize poverty reduction models and paths applicable to different regions or countries.

6. Research prospects

Eradicating poverty and narrowing urban-rural gap have always been the common goal of all mankind and are also the primary task of the United Nations' sustainable development goals by 2030. Poverty geography pays attention not only to regional poverty but also to individual poverty. Scientific poverty reduction and regional sustainable development need the support from relevant findings of poverty geography. In the future, poverty geographers need to focus on the following key fields (Fig. 4).

First, the life cycle evolution law of the IAS needs to be revealed. Geography attaches great importance to the elements, structures, functions of the human-land relationship areal system, and focuses on the process, pattern and the effect of their interaction (Fu, 2017). Regional pauperization is a dynamic process of coupling maladjustment of man, land and industry in a specific area. Poverty geography needs to know how the elements in the IAS interact over time, how its structure and function change, and how the impoverished effect produces through the interaction between the process and pattern of poverty.

Second, poverty is multidimensional and involves many aspects such as geographical environment, social economy, system and culture. Thus, GOP needs to focus on the measurement of regional multidimensional poverty and threshold of impoverishment. Regional impoverishment does not exist at the beginning time but gradually accumulates. Exploring the threshold and key nodes of regional pauperization through system dynamics model helps to deepen the scientific cognition of the essence of poverty, thus supporting national and local anti-poverty making-decision.

Third, GOP needs to explore the areal type and spatial-temporal

The number of people living on less than 2011 PPP \$1.90 a day, 2013 (million)

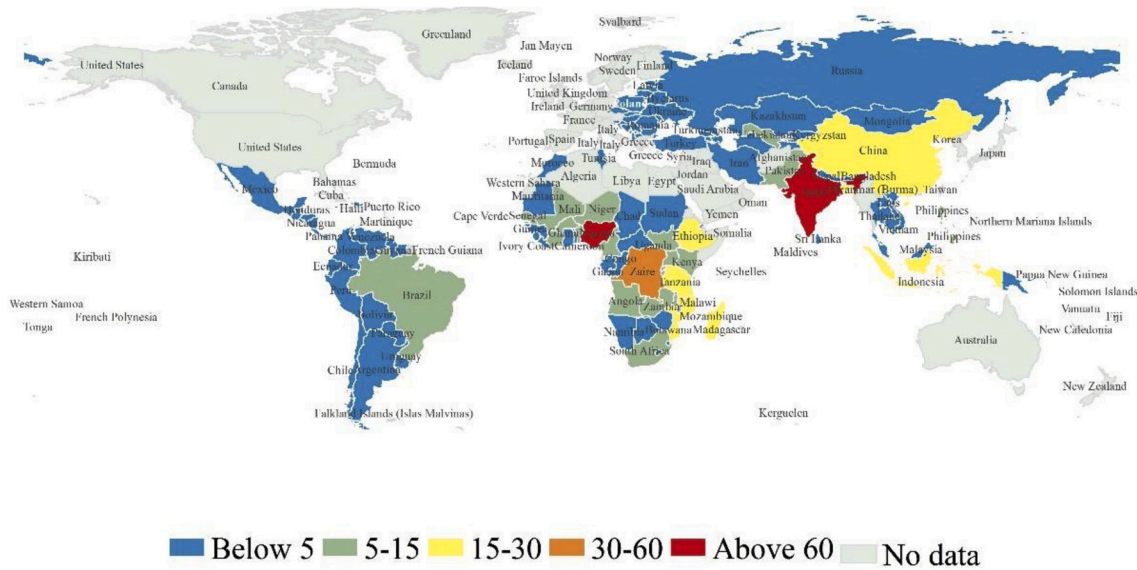


Fig. 3. Global geographical distribution of extreme poverty population. Notes: data are available from Poverty & equity data portal in World Bank (<http://povertydata.worldbank.org/poverty/home/>).

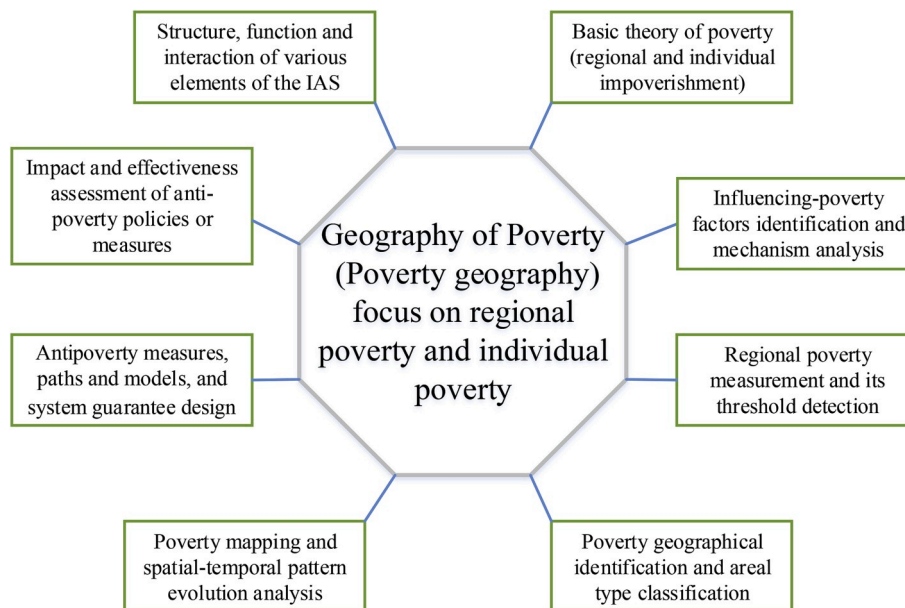


Fig. 4. Main contents of research on poverty geography.

pattern of poverty. It is necessary to develop the method of measuring regional multidimensional/integrated poverty through smaller area estimation and to identify the poverty-stricken areas and the extreme poverty population in these areas, and then divide their type based on poverty level and leading poverty factors. The spatial-temporal pattern of regional impoverishment can be revealed by poverty mapping and spatial analysis technology. It is necessary to deepen the study on the driving mechanism of poverty, analyze the relationship between poverty and geographical capital, carry out dynamic model of regional impoverishment and identify the influencing-poverty factors at different temporal and spatial scales. The identification of multidimensional poverty areas and individuals and its formulation mechanism by big

data model will be one of the important directions of future POG research. Multisource data integration and multidisciplinary intersecting methods in poverty geography will help understand the mechanism of poverty.

Fourth, targeted antipoverty measures need to be considered. How to effectively match them between poor areas and poverty alleviation program is also the scope of POG research. Poverty geography researchers need to delineate the regional types of poverty, identify the real poor in different type-areas and determine the priority areas and groups for poverty alleviation, and explore the feasible paths and development models. Meanwhile, it also needs to estimate the cost of management, the accuracy of targeting and the efficiency of poverty

alleviation funds as well as characteristics of different type areas, and to identify the best geographical scale for poverty alleviation to maximize the effectiveness of antipoverty.

Finally, the poverty reduction effect of anti-poverty policies or measures needs to be scientifically assessed. This requires the introduction of the third-party evaluation mechanism, the establishment of evaluation index system and evaluation method. The third-party assessment system is an important guarantee for promoting the precision of poverty reduction measures and improving the effectiveness of poverty alleviation. China has made many useful explorations in this respect (Li, 2016).

7. Main conclusions

Based on systematic analysis of the significance of poor geography research, this study firstly tried to put forward the IAS, then reviewed the main progress in GOP research and its existing problems, and finally put forward several key problems that need to be answered and the important areas of poverty geography in the future. Our results showed that the IAS can be regarded as an open system with structure and function, which is composed of natural endowments, location conditions, human capital and geographical capital within a certain geographical area and has its life-cycle law. The subsystems of human, land, industry is the core of the IAS. Due to the different emphasis of disciplines, previous studies have not considered regional (place) poverty and individual (people) poverty together. Poverty geography needs to focus on man-land relationship in the IAS. No matter regional poverty or individual poverty will be generated in this system. Regional poverty is an external manifestation of the coupling maladjustment of human, land and industry elements in specific human-land areal system. Poverty geography studies the formation mechanism, distribution characteristics, areal types, evolution mechanism of poverty and its relationship with geographical environment as well as antipoverty measures.

Poverty geography studies need to answer 5w + h questions. Key areas of future GOP research include: 1) life cycle law of evolution of the IAS; 2) measurement of regional multidimensional poverty and its threshold; 3) geographical identification of poverty and its areal types as well as spatial-temporal pattern; 4) dynamic simulation of poverty and its mechanism; 5) poverty mapping; 6) determination of the best geographical scale for poverty alleviation, antipoverty measures and antipoverty guarantee system; and 7) poverty reduction effectiveness assessment. We also suggest that poverty geography should strengthen the research on the mechanism and related theories of poverty in the new period, and systematically reveal the interaction mechanism of regional poverty and its geographical environment. In addition, city and countryside are an organism, urban poverty should give the equal attention to rural poverty, especially in developing countries. According the latest data from the World Bank, there are 244 million urban residents living on less than US\$1.90 a day in China in 2015 (World Bank, 2018).

China is one of the countries with the most prominent poverty problem in the world. Great achievements have been made in poverty reduction in China over the past four decades. Geographers have play been playing an important role in depicting the spatio-temporal characteristics of regional poverty, revealing the mechanism of poverty and exploring the path of poverty alleviation. Faced with China's goal of eliminating absolute poverty by 2020, geographers should keep in mind their mission, continue to deepen the study of poverty geography, refine China's targeted poverty alleviation stories, and serve the state's targeted poverty alleviation and rural revitalization strategy. More importantly, poverty geography research should be internationalized, base-based and engineered, and explore the way to solve the global poverty problem with engineering technology, such as land consolidation (Zhou et al., 2018a, 2019). The research on poverty geography should take advantage of big data platform, cloud computing, artificial

intelligence, internet of things, and remote sensing technology to strengthen the mechanism of poverty and the path of poverty alleviation in countries along the Belt and the Road initiative and Sub-Saharan Africa.

Facing the UN's goal of eradicating poverty by 2030, poverty geographers should devote itself to the study of the mechanism of poverty and answer one of the 125 most challenging questions in the world provided by Science magazine since 2005, i.e., why efforts of change poverty in the Sahara have almost all failed? (Science, 2005). Furthermore, geographers should scientifically evaluate the effectiveness of poverty reduction worldwide and in various countries, depict the gap between poverty reduction and sustainable development goals, analyze the constraints affecting the achievement of poverty reduction goals, and propose global and precise poverty reduction strategies and poverty reduction models suitable for different regions. Eradicating poverty is the foundation for revitalizing the countryside worldwide, and GOP's research is helpful to target the breakthrough point of rural revitalization (Liu and Li, 2017; Liu, 2018). These findings will help enrich the theoretical basis and method system of poverty geography, lead the frontier exploration of poverty geography and better play the role of geography in supporting the formulation of anti-poverty policies.

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References

- Agostini, C.A., Brown, P.H., 2011. Cash transfers and poverty reduction in Chile. *J. Reg. Sci.* 51 (3), 604–625.
- Akter, S., Mallick, B., 2013. The poverty–vulnerability–resilience nexus: evidence from Bangladesh. *Ecol. Econ.* 96, 114–124.
- Albertus, M., Diaz-Cayeros, A., Magaloni, B., Weingast, B.R., 2016. Authoritarian survival and poverty traps: land reform in Mexico. *World Dev.* 77, 154–170.
- Alkire, S., Fang, Y., 2018. Dynamics of multidimensional poverty and uni-dimensional income poverty: an evidence of stability analysis from China. *Soc. Indic. Res.* <https://doi.org/10.1007/s11205-018-1895-2>.
- Alkire, S., Foster, J., 2011. Counting and multidimensional poverty measurement. *J. Publ. Econ.* 95 (7), 476–487.
- Alkire, S., Robles, G., 2017. Multidimensional Poverty Index Summer 2017: Brief Methodological Note and Results. OPHI Methodological Note 44. University of Oxford.
- Alkire, S., Santos, M.E., 2014. Measuring acute poverty in the developing world: robustness and scope of the multidimensional poverty index. *World Dev.* 59, 251–274.
- Alkire, S., Seth, S., 2015. Multidimensional poverty reduction in India between 1999 and 2006: where and how? *World Dev.* 72, 93–108.
- Alkire, S., Roche, J.M., Vaz, A., 2017. Changes over time in multidimensional poverty: methodology and results for 34 countries. *World Dev.* 94, 232–249.
- Amato, P.R., Zuo, J., 1992. Rural poverty, urban poverty, and psychological well-being. *Socio. Q.* 33 (2), 229–240.
- Azevedo, V., Robles, M., 2010. Geographical Poverty Traps in Ecuador Using Pseudo Panel Data. Population Association of America Annual Meeting, Texas.
- Bader, C., Bieri, S., Wiesmann, U., Heinimann, A., 2016. Differences between monetary and multidimensional poverty in the Lao PDR: implications for targeting of poverty reduction policies and interventions. *Poverty & Public Policy* 8 (2), 171–197.
- Baker, J.L., Grosh, M.E., 1994. Poverty reduction through geographic targeting: how well does it work. *World Dev.* 22 (7), 983–995.
- Ballas, D., Dorling, D., Hennig, B., 2017. Analysing the regional geography of poverty, austerity and inequality in Europe: a human cartographic perspective. *Reg. Stud.* 51 (1), 174–185.
- Barbier, E.B., 2010. Poverty, development, and environment. *Environ. Dev. Econ.* 15 (6), 635–660.
- Bigman, D., Fofack, H., 2000. Geographical targeting for poverty alleviation: an introduction to the special issue. *World Bank Econ. Rev.* 14 (1), 129–145.
- Bigman, D., Srinivasan, P.V., 2002. Geographical targeting of poverty alleviation programs: methodology and applications in rural India. *J. Pol. Model.* 24 (3), 237–255.
- Bigman, D., Dercon, S., Guillaume, D., Lambotte, M., 2000. Community targeting for poverty reduction in Burkina Faso. *World Bank Econ. Rev.* 14 (1), 167–193.
- Bird, K., Shepherd, A.V., 2003. Livelihoods and chronic poverty in semi-arid Zimbabwe. *World Dev.* 31 (3), 591–610.

- Bird, K., David, H., Shepherd, A., Moore, K., 2002. Chronic Poverty and Remote Rural Areas. Chronic Poverty Research Centre Working Paper No. 13. Available at: SSRN: <https://ssrn.com/abstract=1754490>. or <https://doi.org/10.2139/ssrn.1754490>.
- Bird, K., Higgins, K., Harris, D., 2010. Spatial Poverty Traps: an Overview. *Blumenstock, J., Cadamuro, G., On, R., 2015. Predicting poverty and wealth from mobile phone metadata. Science* 350 (6264), 1073–1076.
- Bourguignon, F., Chakravarty, S.R., 2003. The measurement of multidimensional poverty. *J. Econ. Inequal.* 1 (1), 25–49, 2003.
- Burke, W.J., Jayne, T.S., 2008. Spatial Disadvantages or Spatial Poverty Traps: Household Evidence from Rural Kenya. Michigan State University, Department of Agricultural, Food, and Resource Economics.
- Cao, S., Zhong, B., Yue, H., Zeng, H., Zeng, J., 2009. Development and testing of a sustainable environmental restoration policy on eradicating the poverty trap in China's Changting County. *Proc. Natl. Acad. Sci. U.S.A.* 106 (26), 10712–10716.
- Casillas, C.E., Kammen, D.M., 2010. The energy-poverty-climate nexus. *Science* 330 (6008), 1181–1182.
- Cavendish, W., 2000. Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. *World Dev.* 28 (11), 1979–2003.
- Chambers, R., Salvati, N., Tzavidis, N., 2016. Semiparametric small area estimation for binary outcomes with application to unemployment estimation for local authorities in the UK. *J. Roy. Stat. Soc.* 179, 453–479.
- Chen, S., Ravallion, M., 2007. Absolute poverty measures for the developing world, 1981–2004. *Proc. Natl. Acad. Sci. U.S.A.* 104 (43), 16757–16762.
- Cheng, X., Shuai, C., Wang, J., Li, W., Shuai, J., Liu, Y., 2018. Building a sustainable development model for China's poverty-stricken reservoir regions based on system dynamics. *J. Clean. Prod.* 176, 535–554.
- Christiaensen, L., Demery, L., Paternostro, S., 2003. Economic growth and poverty in sub-saharan Africa. *Messages from the 1990s. World Bank Econ. Rev.* 17 (3), 317–347.
- Chronic Poverty Research Centre (CPRC), 2004. Chronic Poverty Report 2004-05. CPRC, University of Manchester, Manchester.
- Crandall, M.S., Weber, B.A., 2004. Local social and economic conditions, spatial concentrations of poverty, and poverty dynamics. *Am. J. Agric. Econ.* 86 (5), 1276–1281.
- Daimon, T., 2001. The spatial dimension of welfare and poverty: lessons from a regional targeting programme in Indonesia. *Asian Econ. J.* 15 (4), 345–367.
- Danziger, S., Gottschalk, P., 1987. Earnings inequality, the spatial concentration of poverty, and the underclass. *Am. Econ. Rev.* 77 (2), 211–215.
- Dasgupta, S., Deichmann, U., Meisner, C., Wheeler, D., 2005. Where is the poverty-environment nexus? Evidence from Cambodia, Lao PDR, and Vietnam. *World Dev.* 33 (4), 617–638.
- Datt, G., Hoogeveen, H., 2003. El niño or el peso? Crisis, poverty and income distribution in the Philippines. *World Dev.* 31, 1103–1124.
- de la Fuente, A., Murr, A., Rascón, E., 2015. Mapping Subnational Poverty in Zambia. World Bank, Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/21783> License: CC BY 3.0 IGO.
- Deichmann, U., 1999. Geographic Aspects of Inequality and poverty. Text for the World Bank Web Site on Inequality, Poverty, and Socioeconomic Performance, 1999. <http://www.worldbank.org/poverty/inequal/index.htm>.
- Deutsch, J., Silber, J., 2005. Measuring multidimensional poverty: an empirical comparison of various approaches. *Rev. Income Wealth* 51 (1), 145–174.
- Ding, J., Leng, Z., 2018. Regional poverty analysis in a view of geography science. *Acta Geograph. Sin.* 73 (2), 232–247.
- Do, Q.T., Iyer, L., 2010. Geography, poverty and conflict in Nepal. *J. Peace Res.* 47 (6), 735–748.
- Du, Y., Park, A., Wang, S., 2005. Migration and rural poverty in China. *J. Comp. Econ.* 33 (4), 688–709, 2005.
- Edward, P., Sumner, A., 2014. Estimating the scale and geography of global poverty now and in the future: how much difference do method and assumptions make? *World Dev.* 58, 67–82.
- Elbers, C., Lanjouw, J.O., Lanjouw, P., 2003. Micro-level estimation of poverty and inequality. *Econometrica* 71 (1), 355–364.
- Elbers, C., Fujii, T., Lanjouw, P., Özler, B., Yin, W., 2007. Poverty alleviation through geographic targeting: how much does disaggregation help? *J. Dev. Econ.* 83 (1), 198–213.
- Erenstein, O., Hellin, J., Chandna, P., 2010. Poverty mapping based on livelihood assets: a meso-level application in the Indo-Gangetic Plains, India. *Appl. Geogr.* 30 (1), 112–125.
- Esteban, M.D., Morales, D., Pérez, A., Santamaña, L., 2012. Two area-level time models for estimating small area poverty indicators. *J. Indian Soc. Agric. Stat.* 66, 75–89.
- Fofack, H., 2000. Combining light monitoring surveys with integrated surveys to improve targeting for poverty reduction: the case of Ghana. *World Bank Econ. Rev.* 14 (1), 195–219.
- Foster, J.E., 1998. Absolute versus relative poverty. *Am. Econ. Rev.* 88 (2), 335–341.
- Fu, B., 2014. The integrated studies of geography: coupling of patterns and processes. *Acta Geograph. Sin.* 69 (8), 1052–1059.
- Fu, B., 2017. Geography: from knowledge, science to decision making support. *Acta Geograph. Sin.* 72 (11), 1923–1392.
- Fujita, M., Krugman, P., Venables, T., 1999. *The Spatial Economy: Cities, Regions and International Trade*. MIT Press, Cambridge, MA.
- Gauci, A., 2005. *Spatial Maps. Targeting & Mapping Poverty*. United Nations. Economic Commission for Africa, London.
- Gentle, P., Maraseni, T.N., 2012. Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environ. Sci. Policy* 21, 24–34.
- Gray, L.C., Moseley, W.G., 2005. A geographical perspective on poverty-environment interactions. *Geogr. J.* 171 (1), 9–23.
- Green, A.E., 1994. *The Geography of Poverty and Wealth*. The Institute for Employment Research, University of Warwick, Warwick, UK.
- Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., Nobel, I.O., 2013. Policy: sustainable development goals for people and planet. *Nature* 495 (7441), 305–307.
- Guo, Y., Zhou, Y., Cao, Z., 2018. Geographical patterns and anti-poverty targeting post-2020 in China. *J. Geogr. Sci.* 28, 1810–1824.
- Gurieva, S., Vakulenko, E., 2015. Breaking out of poverty traps: internal migration and interregional convergence in Russia. *J. Comp. Econ.* 43 (3), 633–649.
- Hallegatte, S., 2012. *An Exploration of the Link between Development, Economic Growth, and Natural Risk*. World Bank, Washington, DC. Policy Research Working Paper 6216.
- Hallegatte, S., Adrien, V., Mook, B., Rozenberg, J., 2017. *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters*. Climate Change and Development Series. World Bank, Washington, DC. <https://doi.org/10.1596/978-1-4648-1003-9>.
- Harris, C.D., 1954. The market as a factor in the localization of production. *Ann. Assoc. Am. Geogr.* 44, 35–48.
- Henninger, N., Snel, M., 2002. *Where Are the Poor? Experiences with the Development and Use of Poverty Maps*. World Resources Institute/UNEP/GRID-Arendal, Washington, DC.
- Hertel, T.W., Rosch, S.D., 2010. Climate change, agriculture, and poverty. *Appl. Econ. Perspect. Policy* 32 (3), 355–385.
- Hobza, T., Morales, D., 2016. Empirical best prediction under unit-level logit mixed models. *J. Off. Stat.* 32, 661–669.
- Hulme, D., Shepherd, A., 2003. Conceptualizing chronic poverty. *World Dev.* 31 (3), 403–423.
- Jalan, J., Ravallion, M., 1997. *Spatial Poverty Traps?* World Bank Policy Research Working Paper No. 1862. Available at: SSRN: <https://ssrn.com/abstract=597203>.
- Jalan, J., Ravallion, M., 1998. Transient poverty in postreform rural China. *J. Comp. Econ.* 26 (2), 338–357.
- Jalan, J., Ravallion, M., 2002. Geographic poverty traps? A micro model of consumption growth in rural China. *J. Appl. Econ.* 17 (4), 329–346.
- Jean, N., Burke, M., Xie, M., Davis, W., Lobell, D.B., Ermon, S., 2016. Combining satellite imagery and machine learning to predict poverty. *Science* 353 (6301), 790–794.
- Kanbur, R., Sumner, A., 2012. Poor countries or poor people? Development assistance and the new geography of global poverty. *J. Int. Dev.* 24 (6), 686–695.
- Kodras, J.E., 1997. The changing map of American poverty in an era of economic restructuring and political realignment. *Econ. Geogr.* 73 (1), 67–93.
- Kolenikov, S., Shorrocks, A., 2005. A decomposition analysis of regional poverty in Russia. *Rev. Dev. Econ.* 9 (1), 25–46.
- Kraay, A., McKenzie, D., 2014. Do poverty traps exist? Assessing the evidence. *J. Econ. Perspect.* 28 (3), 127–148.
- Krugman, P., 1991. Increasing returns and economic geography. *J. Polit. Econ.* 99 (3), 483–499.
- Krugman, P., 1995. *Development, Geography and Economic Theory*. MIT Press, Cambridge, MA.
- Krugman, P., Venables, A.J., 1995. Globalization and the inequality of Nations. *Q. J. Econ.* 110 (4), 857–880.
- Li, Y., 2016. Geographers presided over the third-party assessment major tasks of poverty alleviation effectiveness the National Targeted Poverty Alleviation Precision. *Acta Geograph. Sin.* 71 (7), 1272–1273 (in Chinese).
- Li, Y., Long, H., Liu, Y., 2015. Spatio-temporal pattern of China's rural development: a rurality index perspective. *J. Rural Stud.* 38, 12–26.
- Liu, Y., 2018. Research on the urban-rural integration and rural revitalization in the new era in China. *Acta Geograph. Sin.* 73 (4), 637–650.
- Liu, Y., Li, Y., 2017. Revitalize the world's countryside. *Nature* 548 (7667), 275–277.
- Liu, Y., Xu, Y., 2016. A geographic identification of multidimensional poverty in rural China under the framework of sustainable livelihoods analysis. *Appl. Geogr.* 73, 62–76.
- Liu, Y., Liu, Y., Zhai, R., 2009. Geographical research and optimizing practice of rural hollowing in China. *Acta Geograph. Sin.* 64 (10), 1193–1202.
- Liu, X., Su, X., Wang, Y., Zhao, Y., Huang, Y., 2014. Review on spatial poverty and deprivation and its enlightenments to poverty geography studies in China. *Arid. Land Geogr.* 37 (1), 144–152.
- Liu, J., Zou, C., Gao, J., Ma, S., Wang, W., Wu, K., Liu, Y., 2015. Location determination of ecologically vulnerable regions in China. *Biodivers. Sci.* 23 (6), 725–732.
- Liu, Y., Zhou, Y., Liu, J., 2016. Regional differentiation characteristics of rural poverty and targeted poverty alleviation strategy in China. *Bull. Chin. Acad. Sci.* 31 (3), 269–278.
- Liu, Y., Liu, J., Zhou, Y., 2017. Spatio-temporal patterns of rural poverty in China and targeted poverty alleviation strategies. *J. Rural Stud.* 52, 66–75.
- Liu, Y., Guo, Y., Zhou, Y., 2018. Poverty alleviation in rural China: policy changes, future challenges and policy implications. *China Agricultural Economic Review* 10 (2), 241–259.
- Long, H., 2013. Land consolidation and rural spatial restructuring. *Acta Geograph. Sin.* 68 (8), 1019–1102.
- Long, H., Tu, S., Ge, D., Li, T., Liu, Y., 2016. The allocation and management of critical resources in rural China under restructuring: problems and prospects. *J. Rural Stud.* 47, 392–412.
- Lufumpa, C.L., 2005. The poverty-environment nexus in Africa. *Afr. Dev. Rev.* 17 (3), 366–381.
- Luo, Q., Li, X., 2014. Research progress on rural poverty geography in foreign countries. *Econ. Geogr.* 34 (6), 1–7.

- Ma, Z., Chen, X., Chen, H., 2018. Multi-scale spatial patterns and influencing factors of rural poverty: a case study in the liupan mountain region, gansu province, China. *Chin. Geogr. Sci.* 28 (2), 296–312.
- Marchetti, S., Beręsewicz, M., Salvati, N., Szymkowiak, M., Wawrowski, L., 2018. The use of a three-level M-quantile model to map poverty at local administrative unit 1 in Poland. *J. Roy. Stat. Soc.* <https://doi.org/10.1111/rssa.12349>.
- Marhuenda, Y., Molina, I., Morales, D., Rao, J.N.K., 2017. Poverty mapping in small areas under a twofold nested error regression model. *J. Roy. Stat. Soc.* 180 (4), 1111–1136.
- Meen, G., 2009. Modelling local spatial poverty traps in England. *Hous. Stud.* 24 (1), 127–147.
- Milbourne, P., 2004. The local geographies of poverty: a rural case-study. *Geoforum* 35 (5), 559–575.
- Milbourne, P., 2010. The geographies of poverty and welfare. *Geography Compass* 4 (2), 158–171.
- Minot, N., Baulch, B., 2005. Poverty mapping with aggregate census data: what is the loss in precision? *Rev. Dev. Econ.* 9 (1), 5–24.
- Minot, N., Baulch, B., Epprecht, M., 2003. Poverty and Inequality in Vietnam: Spatial Patterns and Geographic Determinants. IFPRI and IDS, Washington, DC and Brighton.
- Minot, N., Baulch, B., Epprecht, M., 2006. Poverty and Inequality in Vietnam: Spatial Patterns and Geographic Determinants, Research Reports 148. International Food Policy Research Institute (IFPRI).
- Molina, I., Rao, J.N.K., 2010. Small area estimation of poverty indicators. *Can. J. Stat.* 38, 369–385.
- Molina, I., Nandram, B., Rao, J.N.K., 2015. Small area estimation of general parameters with application to poverty indicators: a hierarchical Bayes approach. *Ann. Appl. Stat.* 8, 852–885.
- Okwi, P.O., Ndeng'e, G., Kristjanson, P., Arunga, M., Notenbaert, A., Omolo, A., Henninge, N., Benson, T., Kariuki, P., Owuor, J., 2007. Spatial determinants of poverty in rural Kenya. *Proc. Natl. Acad. Sci. U.S.A.* 104 (43), 16769–16774.
- Park, A., Wang, S., 2010. Community development and poverty alleviation: an evaluation of China's poor village investment program. *J. Publ. Econ.* 94 (9), 790–799.
- Park, A., Wang, S., Wu, G., 2002. Regional poverty targeting in China. *J. Publ. Econ.* 86 (1), 123–153.
- Partridge, M.D., Rickman, D.S., 2008. Distance from urban agglomeration economies and rural poverty. *J. Reg. Sci.* 48 (2), 285–310.
- Pokhriyal, N., Jacques, D.C., 2017. Combining disparate data sources for improved poverty prediction and mapping. *Proc. Natl. Acad. Sci. U.S.A.* 114 (46), E9783–E9792.
- Powell, M., Boyne, G., Ashworth, R., 2001. Towards a geography of people poverty and place poverty. *Pol. Polit.* 29 (3), 243–258.
- Ravallion, M., Wodon, Q., 1999. Poor areas, or only poor people? *J. Reg. Sci.* 39 (4), 681–711.
- Rodriguez-Oreggia, E., de la Fuente, A., de la Torre, R., Moreno, H.A., 2013. Natural disasters, human development and poverty at the municipal level in Mexico. *J. Dev. Stud.* 49, 442–455.
- Rozenberg, J., Hallegatte, S., 2016. Model and Methods for Estimating the Number of People Living in Extreme Poverty Because of the Direct Impacts of Natural Disasters. World Bank Policy Research Working Paper No. 7887.
- Rupasingha, A., Goetz, S.J., 2007. Social and political forces as determinants of poverty: a spatial analysis. *J. Soc. Econ.* 36 (4), 650–671.
- Sachs, J., 2008. The end of poverty: economic possibilities for our time. *Eur. J. Dent. Educ.* 12, 17–21.
- Sachs, J.D., Mellinger, A.D., Gallup, J.L., 2001. The geography of poverty and wealth. *Sci. Am.* 284 (3), 70–75.
- Santos, M.E., Villatoro, P., 2018. A multidimensional poverty index for Latin America. *Rev. Income Wealth* 64 (1), 52–82.
- Savard, L., 2005. Poverty and inequality analysis within a CGE framework: a comparative analysis of the representative agent and microsimulation approaches. *Dev. Policy Rev.* 23 (3), 313–331.
- Schady, Norbert, R., 2002. Picking the poor: indicators for geographic targeting in Peru. *Rev. Income Wealth* 48 (3), 417–433.
- Scherr, S.J., 2000. A downward spiral? Research evidence on the relationship between poverty and natural resource degradation. *Food Policy* 25 (4), 479–498.
- Science, 2005. So much more to know. *Science* 309 (531), 78–102.
- Sen, A., 1982. Poverty and Famines: an Essay on Entitlements and Deprivation. Clarendon Press, Oxford.
- Sen, A., 1985. Well-being, agency and freedom: the Dewey lectures 1984. *J. Philos.* 82 (4), 169–221.
- Shepherd, A., Mitchell, T., Lewis, K., Lenhardt, A.J., Lindsey, S.C., Muir-Wood, R., 2013. The Geography of Poverty, Disaster and Climate Extremes in 2030. Overseas Development Institute.
- Steele, J.E., Sundsøy, P.R., Pezzulo, C., Alegana, V.A., Bird, T.J., Blumenstock, J., Bjelland, J., Engø-Monsen, K., de Montjoye, Y.A., Iqbal, A.M., Hadiuzzaman, K.N., Lu, X., Wetter, E., Tatem, A.J., Bengtsson, L., 2017. Mapping poverty using mobile phone and satellite data. *J. R. Soc. Interface* 14 (127), 20160690.
- Summer, A., 2012. Where do the poor live? *World Dev.* 40 (5), 865–877.
- Tsui, K.Y., 2002. Multidimensional poverty indices. *Soc. Choice Welfare* 19 (1), 69–93.
- Tu, S., Long, H., 2017. Rural restructuring in China: theory, approaches and research prospect. *J. Geogr. Sci.* 27 (10), 1169–1184.
- Tu, S., Long, H., Li, T., Ge, D., 2015. Study on the mechanism and models of villages and towns construction and rural development in China. *Econ. Geogr.* 35 (12), 149–156.
- Tzavidis, N., Salvati, N., Pratesi, M., Chambers, R., 2008. M-quantile models with application to poverty mapping. *Stat. Methods Appl.* 17 (3), 393–411.
- The United Nations Development Programme (UNDP), 1990. Human Development Report 1990. UNDP. Oxford University Press, New York.
- UNDP, 1997. Human Development Report 1997. Oxford University Press, New York.
- UNDP, 2010. Human Development Report 2010: the Real Wealth of Nations: Pathways to Human Development. Palgrave Macmillan, New York, 2010.
- Wang, Y., Chen, Y., 2017. Using VPI to measure poverty-stricken villages in China. *Soc. Indicat. Res.* 133 (3), 833–857.
- Wang, Y., Chen, Y., Chi, Y., Zhao, W., Hu, Z., Duan, F., 2018. Village-level multidimensional poverty measurement in China: where and how. *J. Geogr. Sci.* 28 (10), 1444–1466.
- Ward, P.S., 2016. Transient poverty, poverty dynamics, and vulnerability to poverty: an empirical analysis using a balanced panel from rural China. *World Dev.* 78, 541–553.
- Watmough, G.R., Atkinson, P.M., Saikia, A., Hutton, C.W., 2016. Understanding the evidence base for poverty–environment relationships using remotely sensed satellite data: an example from Assam, India. *World Dev.* 78, 188–203.
- World Bank, 1981. *World Development Report 1981*. Oxford University Press, New York, 1981.
- World Bank, 2018. *Poverty & Equity Data Portal*. <http://povertydata.worldbank.org/poverty/home/>, January 22, 2018.
- Wu, C., 1991. The core of study of geography: man-land relationship areal system. *Econ. Geogr.* 11 (3), 1–6.
- Wu, J.X., He, L.Y., 2018. Urban–rural gap and poverty traps in China: a prefecture level analysis. *Appl. Econ.* 50 (30), 3300–3314.
- Xinhua net, 2018. More than 68 Million Poor Population Are Alleviated over the Past Five Years in China. 2018-2-18. http://www.xinhuanet.com/politics/2018-02/18/c_1122426168.htm.
- Xu, Z., Cai, Z., Wu, S., Huang, X., Liu, J., Su, J., Su, S., Wang, M., 2018. Identifying the geographic indicators of poverty using geographically weighted regression: a case study from qiandongnan miao and dong autonomous prefecture, guizhou, China. *Soc. Indicat. Res.* <https://doi.org/10.1007/s11205-018-1953-9>.
- Zhou, L., Xiong, L.Y., 2018. Natural topographic controls on the spatial distribution of poverty-stricken counties in China. *Appl. Geogr.* 90, 282–292.
- Zhou, Y., Guo, Y., Liu, Y., 2018a. Comprehensive measurement of county poverty and anti-poverty targeting after 2020 in China. *Acta Geograph. Sin.* 73 (8), 1478–1493.
- Zhou, Y., Guo, Y., Liu, Y., 2018b. Targeted poverty alleviation and land policy innovation: some practice and policy implications from China. *Land Use Pol.* 74, 53–65.
- Zhou, Y., Guo, L., Liu, Y., 2019. Land consolidation boosting poverty alleviation in China: theory and practice. *Land Use Pol.* 82, 339–348.