Understanding the Population Density Demarcation Line Based on Spatial Information: The "Hu Line" Postprint

Authors: Guo Huadong, Wang Xinyuan, Wu Bingfang, Li Xinwu

Date: 2016-12-26T00:00:00+00:00

Abstract

"The Hu Huanyong Line" is a population density demarcation line in China extending from Aihui in Heilongjiang to Tengchong in Yunnan in a northeast-southwest direction. Its formation and development are closely related to natural conditions including topography, landforms, climate, hydrology, and other factors, and are even more closely associated with social, economic, and human activities. In the context of China's sustainable economic and social development, Premier Li Keqiang posed three fundamental questions regarding the "Hu Huanyong Line": "Should it be broken? Can it be broken? How can it be broken?" Through comprehensive analysis of spatial information and related spatiotemporal data, combined with field investigations in typical regions, this article presents three key insights: the rationale for why the "Hu Huanyong Line" should be broken, the reasons why it can be broken, and the scientific approach to breaking it. Building upon this foundation, the article further proposes four recommendations for breaking the "Hu Huanyong Line": (1) adopt multi-pronged measures to enhance water resource carrying capacity in western China, and establish a new model for large-scale western development through the linkage of "three industries"; (2) build China's green new energy base and develop energy-intensive yet water-saving high-tech industries; (3) pursue urbanization in western China by combining "clusters" and "belts," and promote balanced development between eastern and western regions through potential tapping and innovation; (4) create a people-oriented environment to attract talents from all fields, and construct a benefit-sharing mechanism to safeguard innovation supply.

Full Text

Preamble

Cognizing Population Density Demarcative Line (Hu Huanyong Line) Based on Space Information

Guo Huadong, Wang Xinyuan, Wu Bingfang, Li Xinwu
Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, Beijing 100094

Abstract

The "Hu Huanyong Line" is a population density demarcation line in China that extends from Aihui in Heilongjiang to Tengchong in Yunnan in a northeast-southwest direction. Its formation and development are closely related to natural conditions such as topography, geomorphology, climate, and hydrology, as well as social, economic, and human activities. Confronting the sustainable development of China's economy and society, Premier Li Keqiang posed three major questions regarding the "Hu Huanyong Line": "Should we break it? Can we break it? How do we break it?" Based on comprehensive analysis of spatial information and relevant spatio-temporal data, combined with field surveys in typical regions, this paper proposes three key insights: the basis for why the Hu Line should be broken, the reasons why it can be broken, and scientific approaches to breaking it. Furthermore, the paper puts forward four specific recommendations for breaking the Hu Line: (1) improving water resource carrying capacity in western China through multiple measures and forging a new development model through the linkage of three industries; (2) building a green new energy base in China and establishing energy-intensive yet water-saving high-tech industries; (3) pursuing western urbanization through the combination of "clusters" and "belts" while promoting balanced development between eastern and western China through potential tapping and innovation; and (4) creating a people-oriented environment to attract various talents and constructing an equitable benefit-sharing mechanism to safeguard innovation supply.

Keywords: Hu Huanyong Line, spatial information, new energy, water resources, ecological environment, Belt and Road, new-type urbanization

DOI: 10.16418/j.issn.1000-3045.2016.12.013

Introduction

On August 30, 2013, Premier Li Keqiang invited relevant experts to Zhongnanhai in Beijing to listen to reports on urbanization research and hold discussions. Regarding the Hu Huanyong Line issue, the Premier posed three questions during the symposium: "Should we break it? Can we break it? How do we break it?"—which we refer to as the "Premier's Three Questions." In November 2014,

while visiting an exhibition on human settlement sciences at the National Museum, Premier Li once again raised the question of "how to break the Hu Huanyong Line." To understand and address this major issue raised by the Premier, we undertook the Chinese Academy of Sciences academic consultation project "Spatio-temporal Cognition of the Hu Huanyong Line: Focusing on the Premier's Three Questions," conducting research primarily based on space-based Earth observation information, supplemented by relevant comprehensive data and surveys along typical regions of the Hu Line.

The "Hu Huanyong Line" (hereinafter referred to as the "Hu Line") was proposed by Chinese geographer Hu Huanyong as a demarcation line dividing China's population density using the "Aihui-Tengchong" line. In 1935, Professor Hu Huanyong, then at Central University, published the paper "The Distribution of China's Population" in *Acta Geographica Sinica*, noting that "in recent years, Chinese and foreign scholars studying China's population issues have been increasing daily. Whether China's population is excessive, whether there remains potential for large-scale migration within the national territory, are actually urgent questions to be answered, with widely divergent opinions on these matters" [1]. Based on 1933 population distribution and density maps, Hu discovered that a line from Aihui in Heilongjiang (now Heihe City) to Tengchong in Yunnan formed a roughly 45° northeast-southwest population density demarcation line, later known as the "Hu Huanyong Line."

The Hu Line holds significant importance in economic production, social development, and scientific research. It is one of the landmark achievements in modern geography completed entirely by Chinese scholars and possesses important value in geography, humanities, economics, and many other fields [2,3]. For many years, the southeast half of the Hu Line, using approximately 2/5 of the national territory, has produced over 90% of GDP and housed over 90% of the population. Today, China's total economic output ranks second in the world. The Fifth Plenary Session of the 18th CPC Central Committee proposed that China would achieve a moderately prosperous society in all respects by 2020, with per capita GDP reaching US$10,000. If development increments remain concentrated on the southeast half of the Hu Line, it will inevitably render land, resources, and environment unsustainable, leading to serious development imbalances between eastern and western China, which is detrimental to harmonious social, economic, and environmental development. However, with water scarcity, fragile ecological environments, and relatively backward infrastructure in northwestern regions, achieving leapfrog development across the 3/5 of national territory in the northwestern half requires an international development strategic vision, a nationally coordinated development approach between east and west, and innovative thinking, methods, and measures to leverage western strengths and advantages and tap into western resources.

1. Understanding the "Premier's Three Questions"

Through systematic analysis, we propose three key insights regarding the "Premier's Three Questions": the basis for why the Hu Line should be broken, the reasons why it can be broken, and scientific approaches to breaking it.

1.1 The Basis for Why the Hu Line Should Be Broken

1.1.1 Population density demarcation lines are dynamic, and the Hu Line, as a modern population density mutation line, lacks justification for remaining permanently unchanged China's current population distribution pattern of dense east and sparse west has evolved continuously throughout historical development. Examining the 2,000 years since the Han Dynasty, through several time periods of the Han, Tang, Ming, and Qing dynasties, China's population pattern has been in constant flux. The trajectory of population density demarcation line changes has shifted from east-west orientation (Han Dynasty) to north-south orientation (Ming Dynasty), and then to northeast-southwest orientation (late Qing Dynasty) [FIGURE:1]. According to research and simulation [4,5], during the Western Han Dynasty, early Chinese agricultural development concentrated in the most densely populated and economically developed middle and lower reaches of the Yellow River basin, with a national population distribution pattern of more north and less south. Using the Yangtze River as the boundary, 81.0% of the population was distributed in the north, while the southern region had less than 20%. By the Eastern Han Dynasty, the population proportion in the area south of the Yangtze River rose to 33.6%, with the north accounting for 66.4%. In the early Tang Dynasty, the north accounted for 45.4% and the south for 54.6%. In the 25th year of the Jiaqing reign of the Qing Dynasty (1820), a population density demarcation line formed extending to Jiayuguan in the west and the eastern edge of the Qinghai-Tibet Plateau, and to the Yunnan border in the southwest. If drawn as a straight line, this population density demarcation line approximated the Hu Line but extended in a 30° northeast-southwest direction. In the 30th year of the Daoguang reign (1850), the national population was approximately 430 million, with 71.4% on the south side of the line and 28.6% on the north side.

Thus, over the past 2,000 years, China's population density demarcation line has been constantly changing. China's population pattern has been continuously evolving from the Han through Tang, Ming, and Qing dynasties. Changes in China's population pattern have occurred alongside the evolution of population, as an agricultural nation, under the combined influences of social, economic, technological, and environmental factors. The Hu Line, as a modern population density mutation line, will not remain unchanged forever.

1.1.2 The proportion of population and GDP in the northwest half of the Hu Line is slowly rising, requiring crossing the Hu Line to change development thinking and conditions for greater, faster development in coordination with the east Based on county-level population census

data and remote sensing observation data, we studied spatial changes in China's population density. From 1935 to 2010, the national average population density increased from 41 persons/km^{2} in 1935 to 144 persons/km^{2} in 2010, an average increase of 100 persons per square kilometer. Significant changes in national average density occurred in 1964 and 1982. Although large areas west of the Hu Line have population densities below the average, the population there has increased from 15 million in 1935 (excluding Mongolia's 3 million) to 88 million in 2010, with the proportion rising from 3.21% in 1935 to 6.51% in 2010 .

From 2004 to 2013, the GDP proportion of the northwest half of the Hu Line rose slowly from 7.74% to 8.78%. Industrial added value increased from 6.41% to 8.58%, agricultural added value from 10.72% to 11.55%, and tertiary industry added value from 7.71% to 7.85%.

Remote sensing can detect nighttime urban lights, small-scale settlements, and even low-intensity lights from traffic flows, clearly distinguishing them from dark rural and environmental backgrounds. Nighttime light brightness reflects both economic prosperity and population aggregation. Through spatial distribution of nighttime lights, macro-scale population distribution patterns can be revealed.

[FIGURE:2] shows the macro-scale population distribution patterns of China and the United States displayed by 2010 satellite DMSP/OLS nighttime light imagery. From the nighttime light remote sensing images, the United States (excluding Alaska) has a nearly north-south oriented population density demarcation line, with the eastern and western sides accounting for 44.55% and 55.45% of the area, respectively, and population proportions of 73.91% and 26.09%. Based on nighttime light data and land cover data estimates, China's 2010 population distribution shows that on either side of the Hu Line, the southeast and northwest account for 43.68% and 56.32% of the area, respectively, and 93.49% and 6.51% of the population. In terms of east-west area ratio, China is similar to the United States, but the gap in population proportions between China's east and west is much larger .

Evidently, population quantity, density, and quality are comprehensive reflections of society, economy, lifestyle, and environment, varying across countries due to different natural and economic conditions, and varying within the same country at different development stages. China's population pattern has been continuously changing from the Han through Tang, Ming, and Qing dynasties. The Hu Line, as a modern population density mutation line, will not remain unchanged forever. As soon as development conditions in the east and west change, this population density demarcation line will change.

Over the past 30 years, China's urbanization has mainly occurred in the farming areas east of the Hu Line, with urban expansion occupying large amounts of high-quality land resources. Remote sensing monitoring of 60 major cities

shows that during the 40-year period from 1973 to 2013, the actual expan-

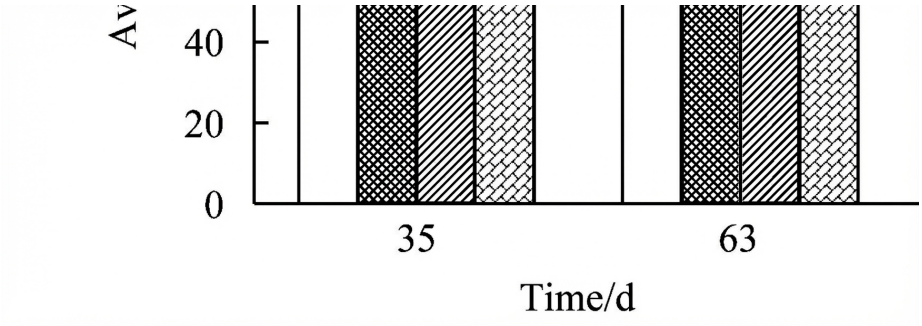

Figure 1: Figure 3

sion area of these 60 major cities was 15,755 km^{2}, of which 56.51% came from occupation of cultivated land. The average central built-up area of these cities increased by 5.23 times. Excessively rapid urbanization has led to over-concentration of population in some mega-cities and urban agglomerations in the east, causing water, soil, and air pollution, placing excessive pressure on the eastern population-resource-environment system and challenging sustainable development.

Remote sensing monitoring also shows that the average per capita construction land area in central China is only 67.28 km^{2}, indicating serious underdevelopment. According to 2010 remote sensing data statistics, unused land area west of the Hu Line accounts for 96.66% of the national total unused land area, of which bare rock and gravel, Gobi desert, and sandy land account for 85%. Under traditional agricultural economic models, these lands are considered "ecologically fragile" "useless lands." However, some of these areas are actually high-yield zones for green energy (solar, wind, etc.) awaiting development. The high mountains and deep valleys, cold and arid environments of the southwest and northwest nurture unique biological resources and ecological products, yet research and development of these resources remain insufficient due to constraints.

From 1935 to 2010, the population west of the Hu Line increased from 3.21% to 6.51% of the national total, a slow rise of 3.3 percentage points over 75 years. The GDP growth rate in the past decade has been relatively faster than the population growth rate. If, in the first half of the 21st century, under the guidance of the new "five modernizations," the western population can increase by another 3%-4% to account for 10% of the national population, western development potential will be more effectively released and accelerated, narrowing the gap between east and west and achieving more balanced development.

1.2 Why the Hu Line Can Be Broken

Against the backdrop of new domestic and international development concepts and technology-driven development, breaking the Hu Line is now supported by the following conditions:

(1) **Utilizing global resources and markets to alleviate western water scarcity is a once-in-a-lifetime opportunity.** Currently, western water resources are mainly used for agricultural irrigation, and this utilization pattern needs adjustment. Using global resources and markets can provide solutions to water scarcity in western China. Taking soybeans as an example, China's soybean imports exceeded 70 million tons in 2014, accounting for over 90% of total domestic demand, equivalent to utilizing 500 million mu of foreign farmland water and soil resources. Similar to soybeans, global bulk grain prices have been far lower than domestic production prices in recent years. Therefore, the time has come to utilize global agricultural product markets to meet domestic demand, particularly to liberate western regions from the "cage" of grain and cotton production, freeing up more water resources for modern industrial development.

(2) **Advanced water-saving measures and water treatment and transfer technologies are the keys to solving western water scarcity.** Water shortage in arid and semi-arid regions is the primary factor limiting their development. China's current water usage shows that per capita water consumption in the east, central, and west is 393 m^{3}, 468 m^{3}, and 545 m^{3}, respectively, with the west having the highest per capita usage. Water consumption per 10,000 yuan GDP is 63 m^{3}, 129 m^{3}, and 158 m^{3}, respectively, with the west having the lowest efficiency. Per mu water consumption for actual irrigated farmland is 379 m^{3}, 378 m^{3}, and 512 m^{3}, respectively, with the west having the highest per mu consumption. Western China's water resource carrying capacity has potential for increase. Today, water-saving irrigation in arid and semi-arid regions has matured technologically. Additionally, water transfer engineering and technology have gradually matured. Scientific water transfer, utilization, and rational water use are important directions for solving water shortage problems in western development.

(3) **Abundant green energy in the west will provide strong power support and development space for future emerging industries.** China's energy resource endowment and demand are geographically imbalanced, with energy resources mainly distributed in western and northern regions, while energy consumption is currently concentrated in eastern regions. The northwest has abundant and stable solar and wind resources, while the southwest has rich hydropower and geothermal resources. Fully utilizing western green energy, adjusting energy consumption structure, and developing a green economy are scientific choices for western future

development. The west can achieve rapid development through new pathways by selecting new industries with low water consumption, high electricity demand, and high technology, such as big data and cloud computing industries that consume little water but much electricity and can be appropriately deployed in the west. Western abundant green energy provides strong power support and development space for future emerging industries.

(4) **Rapid transportation will solve the spatial and psychological distance and barriers caused by difficult travel in the west.** Vast territorial space, rugged terrain, and harsh environments causing transportation difficulties have been another major factor limiting development in the northwest and southwest regions of the Hu Line. Modern transportation technology and modes have undergone revolutionary changes, with long-distance travel now possible within a day or even same-day round trips, greatly weakening terrain constraints on human activities. Convenient transportation is a powerful driving force for continuous population migration. The popularization of fast transportation has greatly eliminated barriers created by distance, making connections between urban and rural areas closer and population mobility much stronger, providing technical guarantees for further breaking the uneven spatial distribution of population across the Hu Line.

(5) **"Internet Plus" will bring major transformations to production, lifestyle, and consumption patterns in the west.** The "Internet Plus" industry provides industrial support for breaking the uneven spatial distribution of population across the Hu Line. With the emergence of "Internet Plus" business models, particularly large e-commerce platforms, buying and selling products has become convenient, making information more symmetrical in every field of economic activity and supply-demand relationships more transparent, providing possibilities for small-batch, distinctive western products to access global markets. The internet changes not only information products but also material products, mobilizing more resources to create value through resource flow and enabling a sharing economy. The internet will bring major transformations to western production and sales, lifestyle, and consumption patterns.

(6) **The national "Belt and Road" strategy and related macro-policies provide the foundation for "breaking" the line.** The intercontinental "Belt and Road" initiative breaks traditional geopolitics, leveraging the spatial coverage attributes of capital and culture, transforming previous "point" connections between cities or regions into point-line-belt (area) connections and coverage. The "Silk Road Economic Belt" crosses the Hu Line through northern, central, and southern routes (belts). Additionally, the implementation of the "Yangtze River Economic Belt" strategy closely connects China's economically developed Yangtze River Delta region with the west. These

national strategies will inevitably lead to rapid development of the social-economic-environmental-population systems in these belt regions, providing a once-in-a-lifetime historical opportunity for balanced development between eastern and western China and becoming important policy foundations and strategic guarantees for breaking the Hu Line [8].

1.3 Scientific Approaches to Breaking the Hu Line

As mentioned above, breaking the Hu Line essentially means breaking the unbalanced development between east and west. How to enable rapid, green development in the west is the main question in breaking the Hu Line. We believe the following five aspects are important: (1) scientific and technological progress provides innovative momentum for breaking the Hu Line; (2) abundant natural and cultural resources provide material foundations; (3) modern economic development models provide broad market space; (4) scientific macro-policy support and guidance provide strong guarantees; and (5) enabling talent to achieve success is the key element.

1.3.1 Clarifying the Connotation of Breaking the Hu Line

(1) **View population, environment, and resource carrying capacity dynamically and dialectically.** Water scarcity and fragile ecological environments in the west are undeniable facts. However, we must view carrying capacity dynamically and dialectically. In fact, environmental carrying capacity is directly related to industry, and its constraints continuously change with human social development. The 36 oasis states in the Western Regions during the Han Dynasty, despite having irrigation agriculture, had low grain yields per mu, and a population of over 10,000 constituted a relatively large "state." Today, Urumqi's population of 3.5 million exceeds the total population of all 36 states at that time. In 1935, the western population of the Hu Line was less than 20 million. Given the agricultural production conditions and land carrying capacity at that time, as Hu Huanyong himself believed, the west could support "at most only a few million to ten million people" [1]. Today, the west of the Hu Line already supports over 88 million people, an unimaginable scenario in 1935.

(2) **The essential connotation of breaking the Hu Line is to break the unbalanced development between east and west.** Breaking the Hu Line does not mean breaking the state of natural factors (such as precipitation, temperature, ecological environment, etc.)—for example, in a region with 200 mm annual precipitation, humans cannot significantly increase rainfall artificially. However, people can change water utilization methods and efficiency and adopt other approaches so that 200 mm of precipitation does not constitute a development constraint. Breaking the Hu Line also does not mean conducting large-scale traditional agricultural production in the west, nor does it mean massive westward migration of

population. When we discuss whether we can break the Hu Line, we refer to leveraging modern technology, new production methods, new business models, and modern capital operations, under scientific policy guidance, to develop the west, eliminate poverty, and achieve balanced development between east and west through synchronized development measures of agricultural modernization, new-type urbanization, new-type industrialization, informatization, and greenization, thereby attaining coordinated development of society, economy, and ecology.

2. Four Recommendations for Breaking the Hu Line

2.1 Improving Western Water Resource Carrying Capacity Through Multiple Measures and Forging a New Development Model Through "Three Industries" Linkage

(1) **Control cultivated land scale, adjust planting structure, and transform management methods to improve water resource carrying capacity.** Given the severe water shortage situation in the west, regions west of the Hu Line, especially northwestern areas, should strengthen monitoring of cultivated land scale and water consumption, and promote adjustment of agricultural planting structures. For example, at the Xinjiang Bozhou Irrigation Experimental Station, water productivity increased by 0.11 kg/m^{3} through water consumption-controlled efficient water-saving irrigation of goji berries, with per mu water consumption reduced by 58 m^{3} compared to cotton, achieving obvious water-saving effects. While ensuring basic food grain supply, transforming management methods and appropriately importing high water-consuming bulk crops can achieve "virtual water" transfer. Producing one mu of cotton in the west consumes about 450 m^{3} of water, while producing one mu of rice requires 800-1,000 m^{3}. Conversely, importing high water-consuming crops like cotton and rice essentially means importing water resources, saving more water for western ecological environment restoration, residential water use, and low water-consuming industries, thereby helping break the constraint of water shortage on western development and improving western water resource carrying capacity.

Simultaneously, we must strictly implement the "three red lines" of total water resource control, water use efficiency, and water environment control; strengthen water treatment technology to improve sewage recycling rates; and conduct feasibility studies and planning for "Tibetan water to Xinjiang" and other water transfer schemes to solve western water shortage through multiple channels [9].

(2) **Develop western characteristic high value-added ecological industries to forge new engines for western economic growth and social development.** The linkage development of ecological industry, ecological agriculture, and ecological services will be one of the effective pathways for the west to achieve leapfrog development. We should lever-

age western unique ecological advantages, gradually abandon low-quality, water-consuming grain and cotton planting models, and pursue quality-oriented premium agricultural development to improve water productivity and quality. Due to the personalized, characteristic ecological environment of the west, characteristic ecological products are produced. Based on "Internet Plus" and oriented toward the global market, we should shape China's western high-end agricultural image and build an "Internet Plus" industry supported by characteristic fruit and green product production and processing, transforming the west into a healthy, water-saving, high-value-added premium ecological agriculture and agricultural product processing base in China.

The west is also a place of rich cultural, landscape, ethnic, and lifestyle diversity. We should develop western unique tourism resources using modern large-scale tourism concepts and develop ecological and cultural service industries. The "large tourism economy" concept uses tourism industry development as the foundation and connecting link to fully integrate relevant tourism elements into the synchronized development process of new industrialization, informatization, new urbanization, and agricultural modernization, as well as ecological environmental protection, forming a comprehensive, correlated, and ecological economic development and ecological protection collaborative promotion system.

2.2 Building a Green New Energy Base in China and Establishing Energy-Intensive yet Water-Saving High-Tech Industries

(1) **Develop abundant green new energy in the west and build it into China's green new energy base.** China's northwest has abundant and stable solar and wind resources, while the southwest has rich hydropower and geothermal resources. Fully utilizing western green energy, adjusting energy consumption structure, and developing a green economy are scientific choices for western future development. As new energy development and utilization technologies mature, we should undertake overall planning for western green energy development and scientific layout, and promptly build the west into an important national green energy supply base to improve China's energy structure and pursue low-carbon green development.

(2) **Vigorously promote and encourage green energy consumption to create energy-intensive and water-saving high-tech industries in the west.** We should give full play to western green energy advantages and vigorously advocate green energy consumption. To partially solve the problem of western energy being sent eastward, the west can deploy high-tech industries with high energy consumption, low water demand, high technical requirements, and small environmental costs, promoting a new industrial revolution in the west. "Transporting coal is inferior to transmitting electricity, and transmitting electricity is inferior to transmitting information." The layout of big data industries such as cloud

bases and new-generation data centers in the west will have a leapfrog development effect. Additionally, given the scattered settlements in the west, widespread green energy can be used to solve rural residents' electricity problems. We should actively promote solar water heaters, solar cookers, solar thermal power generation systems, solar panels, and new energy vehicles in rural areas. Based on summarizing existing green energy development experience, we should promptly conduct research and planning on light-heat and light-electricity conversion, and deploy a batch of major green energy projects in suitable western areas.

2.3 Pursuing Western Urbanization Through "Clusters" and "Belts" and Promoting Balanced Development Between East and West Through Potential Tapping and Innovation

(1) **Leverage late-mover advantages to cultivate new growth points and create a western urbanization model combining "clusters" and "belts."** The "Belt and Road" strategy implementation will cultivate a batch of growth poles and belts. The west should seize national opportunities for border and inland opening, leverage late-mover advantages, and explore new growth poles (points) and growth belts (lines). For example, both Xinjiang in the northwest and Yunnan in the southwest border several countries and occupy important bridgehead positions in the construction of the northern and southern belts of the "Silk Road," with border ports and open economic corridors providing major development opportunities.

Optimizing urbanization layout is one of the strategic tasks of urbanization development in the new era. The spatial structure development model of the western regional urban system should incorporate the millennia-old oasis-based linear (belt) city-town-village combinations and pursue a development model combining urban agglomerations with city-town-village-enterprise belts to drive rural and regional economic development. Currently, besides constructing the Tianshan North Rim Economic Belt, we should also promptly plan a green urban belt along the southern side of the Tianshan Mountains (northern rim of the Tarim Basin) linking cities, towns, villages, and enterprises, pursuing military-civilian integrated development to drive development in the Tarim Basin periphery, including southern Xinjiang.

(2) **Unlock the huge potential of western urbanization development and promote balanced socio-economic development between eastern and western China.** Promoting urbanization is a necessary path to modernization. Remote sensing monitoring shows that from 1973 to 2013, the built-up area of major cities nationwide expanded by 5.23 times, with 56.51% of urban expansion land coming from cultivated land. The urban land expansion speed in areas east of the Hu Line is 23 times that in western areas, reflecting serious imbalances in urbanization development between eastern and western regions and the urgent task of

initiating western urbanization development in the next stage.

Under the new era, the goal of promoting urbanization is to improve urbanization quality, including improving urban land use efficiency and appropriate population density in built-up areas. Using remote sensing technology to monitor China's urban land scale, combined with 2010 urban population and temporary population data from the China Urban Construction Statistical Yearbook, research shows that China's urban land intensification level is relatively low, with per capita construction land area of 129.06 m^{2}, indicating potential within urban areas to absorb new urban population. The average per capita construction land area in cities west of the Hu Line is 166.21 m^{2}, indicating significant potential for internal tapping. Based on urban construction land calculations, urban land potential in areas west of the Hu Line ranges from 500 to 5,300 km^{2}, capable of supporting an urban population of 480 to 500 million.

2.4 Creating a People-Oriented Environment to Attract Various Talents and Constructing an Equitable Benefit-Sharing Mechanism to Safeguard Innovation Supply

(1) **Create an environment to incentivize various talents to start businesses in the west and develop education to cultivate backup talent that takes root in the west.** People-oriented systems and infrastructure construction are important means to attract people. Through institutionalized and systematic management, we should improve service and management levels, providing everyone with comprehensive, systematic, and continuous incentives that give them a sense of respect, pride, and achievement. The key to emerging industries lies in people. While strengthening hardware environment construction in areas west of the Hu Line, it is more important to have forward-thinking in talent introduction. We should fully leverage land reserve advantages and climate advantages to formulate better talent introduction policies than those in the east, solve worries about innovation and entrepreneurship, attract talent to settle and develop in the west, and retain talent for successful entrepreneurship in the west. We should use moderately advanced education strategies to cultivate human resources needed for western development. It is recommended that the state integrate some higher education institutions and research institutes to establish several comprehensive and specialized universities and colleges in western regions, focusing on new energy, new materials, aerospace technology, Earth observation, Internet Plus, big data, cloud computing, green economy, ecological restoration and utilization, characteristic medicine, characteristic food processing, characteristic tourism, and modern management, to cultivate high-level new technology and management talents for western regions and drive long-term, stable development of western high-tech industries. We should vigorously develop ethnic cultural education and vocational education in western areas to form balanced, gradient development of educational resources and levels. We

should introduce preferential policies in entrepreneurship and settlement to incentivize western talent to take root, grow roots, and develop through entrepreneurship locally.

(2) **Build a secure and stable environment with relaxed policy systems and establish mechanisms for equitable resource distribution and benefit sharing.** Attracting talent, technology, and capital for innovation, entrepreneurship, and investment is a prerequisite for development in areas west of the Hu Line. Besides convenient and high-quality hardware facilities, a safe production and living environment and people-oriented policy and institutional environment are key measures and guarantees for attracting talent. Breaking the Hu Line and achieving great western development is most constrained by talent shortage. To develop, the west must recruit talent without rigid adherence to conventional patterns. Entrepreneurs can contract land, define property rights with local governments and residents, and share the dividends brought by reforms in land use methods and management models. Western development involves multiple stakeholders including local residents and managers, external entrepreneurs and investors, and national and local governments. Development dividends should be distributed reasonably and fairly under mechanisms that promote equitable resource distribution and benefit sharing. Scientific management and production innovation talents are both scarce resources and should be given sufficient preferential policies and material and spiritual rewards to attract them to the "west," which is considered "unsuitable for human habitation" and "unproductive," for innovation and entrepreneurship.

References

1. Hu Huanyong. The distribution of China's population. *Acta Geographica Sinica*, 1935, 2(2): 33-74.
2. Wang Zheng, Zhang Piyuan, Zhou Qingbo. The impact of historical climate change on Chinese social development: with a discussion on human-environment relations. *Acta Geographica Sinica*, 1996, (4): 329-339.
3. Ge Jianxiong. *Ge Jianxiong's Collected Works 2: Hundreds of Millions of People*. Guangzhou: Guangdong People's Publishing House, 2014.
4. Wu Jing, Wang Zheng. Agent-based simulation analysis of China's population geography evolution over the past 2000 years. *Acta Geographica Sinica*, 2008, 63(2): 185-194.
5. Zhang Jianchun, Chu Shaolin, Chen Quangong. Current status and progress in defining China's agricultural-pastoral ecotone. *Prataculturral Science*, 2008, 25(3): 78-84.
6. Zhang Zengxiang, et al. *Atlas of Remote Sensing Monitoring of Urban Expansion in China*. Beijing: Xingqiu Map Press, 2014.

7. Guo Huadong, Xiao Han. Space observation of the "Belt and Road" and construction of the "Digital Silk Road". *Bulletin of Chinese Academy of Sciences*, 2016, 31(5): 535-541.

8. Wu Bingfang, Zeng Hongwei, Chen Xi. Cultivated land use patterns of the "Silk Road Economic Belt" based on spatial cognition. *Bulletin of Chinese Academy of Sciences*, 2016, 31(5): 542-549.

Acknowledgments

We thank Fan Baomin, Liu Haiqi, Zhang Wentao, Hua Guang, Zhang Zengxiang, Wang Shixin, Zhao Xiaoli, Liu Yalan, Zhou Yi, Wang Qinjun, Sun Zhongchang, Chen Fulong, Liu Chuansheng, and others for their support and contributions. Li Li and Luo Lei assisted in collecting materials and mapping. We express our gratitude to Xinjiang, Shaanxi, Ningxia, Gansu, Henan, Yunnan, and other provinces and regions for their strong support for our research! We extend our thanks to all!

Guo Huadong is a professor at the Institute of Remote Sensing and Digital Earth (RADI), Chinese Academy of Sciences (CAS), an Academician of CAS, a Fellow of the World Academy of Sciences for the Advancement of Science in Developing Countries (TWAS), and an Academician of the International Eurasian Academy of Sciences (IEAS). He presently serves as President of the International Society for Digital Earth (ISDE), Past-President of the ICSU Committee on Data for Science and Technology (CODATA), Science Committee Member of the Integrated Research on Disaster Risk (IRDR) programme co-sponsored by ICSU, ISSC, and UNISDR, Editor-in-Chief of the *International Journal of Digital Earth*, and Chairman of the Chinese National Committee for ISDE and China Committee for IRDR. He specializes in remote sensing science and its applications, and has conducted ground-breaking research on the information mechanisms of remote sensing, radar for Earth observation, and Digital Earth science. Prof. Guo has published more than 400 papers and 16 books, and is the principal awardee of 13 national and CAS prizes. E-mail: hdguo@radi.ac.cn