Population and Water-Soil Resources Carrying Capacity of Xiong' an New Area (Postprint)

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Abstract

The establishment of the Xiong' an New Area in Hebei represents a historic strategic decision by the Party Central Committee with Comrade Xi Jinping at its core to advance the coordinated development of the Beijing-Tianjin-Hebei region. Currently in the planning and construction phase, it is imperative to investigate the resource and environmental carrying capacity and support levels to provide scientific basis and decision-making support for the new area' s development. This study, grounded in the Xiong' an New Area while considering the broader Beijing-Tianjin-Hebei context, quantitatively evaluates and comparatively analyzes the population and water-land resource carrying capacity of the Xiong' an New Area and its surrounding regions, based on population distribution and the relationships between population and grain, as well as population and water. The findings indicate that the Xiong' an New Area possesses superior land resource carrying capacity compared to surrounding areas, with a coordinated population-grain relationship and remaining potential for population agglomeration; however, its water resource carrying capacity is inferior to surrounding areas, characterized by a tense population-water relationship, necessitating both intra-basin water allocation and inter-basin water transfer. Building upon these results, several recommendations are put forward to promote rational population distribution, guide orderly population mobility, and enhance water-land resource carrying capacity.

Full Text

Abstract

The establishment of Xiongan New Area represents a historic strategic decision by the Party Central Committee with Comrade Xi Jinping at its core to advance the coordinated development of the Beijing-Tianjin-Hebei region. As Xiongan New Area is currently in the planning and construction phase, it is imperative to ascertain its resource and environmental carrying capacity and

security levels to provide scientific basis and decision-making support for the new area' s development. This study focuses on Xiongan New Area within the broader context of the Beijing-Tianjin-Hebei region, quantitatively evaluating and comparatively analyzing the population and water-land resource carrying capacity of Xiongan and its surrounding areas based on population distribution patterns and human-grain and human-water relationships.

The research indicates that Xiongan New Area's land resource carrying capacity surpasses that of surrounding regions, with a harmonious human-grain relationship that still accommodates additional population agglomeration. However, its water resource carrying capacity is inferior to surrounding areas, characterized by tense human-water relations that necessitate both intra-basin water allocation and inter-basin water transfer. Building upon these findings, we propose several recommendations to promote rational population distribution, guide orderly population mobility, and enhance water-land resource carrying capacity.

Keywords: Xiongan New Area, population, land resources, water resources, resource and environmental carrying capacity

1. Introduction

The establishment of Hebei Xiongan New Area constitutes a major strategic decision by the Party Central Committee with Comrade Xi Jinping at its core to deepen coordinated Beijing-Tianjin-Hebei development and orderly relieve Beijing of non-capital functions. As China' s third nationally significant new area following the Shenzhen Special Economic Zone and Shanghai Pudong New Area, Xiongan represents a millennial project and national priority [1]. Developing Xiongan New Area holds profound historical significance and practical importance for orderly relieving Beijing of non-capital functions, exploring new models for optimizing development in densely populated economic regions, and adjusting and optimizing the urban layout and spatial structure of the Beijing-Tianjin-Hebei region.

To avoid resource and environmental problems triggered by population agglomeration during urbanization, green development represents a critical challenge for both Xiongan New Area construction and Beijing-Tianjin-Hebei coordinated development [2,3]. Consequently, resource and environmental carrying capacity and security levels have become priority concerns in Xiongan' s planning and construction [3]. Resource and environmental carrying capacity encompasses both resource carrying capacity and environmental carrying capacity (capacity) in a comprehensive framework [4]. Generally, it refers to the population and economic scale that can be supported by the resource endowment and environmental capacity of a given territorial space, provided that the natural ecological environment remains unharmed and healthy ecosystems are maintained [5,6]. The concept originated in the late 18th century and, after more than 200 years of development, has become an important concept and key indicator for describing regional development constraints [4,7], and in recent years has

been applied as a critical control factor in national and local planning as well as post-disaster reconstruction [2,8]. Given the fundamental importance of resource and environmental carrying capacity to Xiongan New Area' s planning and construction, this paper examines the interrelationships among population, resources, environment, and development, conducting preliminary analysis and evaluation of population and water-land resource carrying capacity in Xiongan and its surrounding areas based on land resource carrying capacity derived from human-grain relationships and water resource carrying capacity derived from human-water relationships. On this basis, we propose recommendations to promote coordinated development between population and resource environment in Xiongan New Area.

2. Population Development in Xiongan New Area and Surrounding Regions

2.1 Population Growth Trends (1953-2015)

From 1953 to 2015, the population of Xiongan New Area and its surrounding regions increased synchronously, with growth rates lower than Hebei Province and far lower than Beijing and Tianjin. During this period, Xiongan' s population grew continuously, with growth rates slightly higher than Hebei but far below those of Beijing and Tianjin. Between 1990 and 2015, Xiongan New Area' s average annual population growth rate was basically consistent, slightly higher than the average levels of Hebei Province and the national average, but far lower than Beijing and Tianjin, with an accelerating trend since 2010 (Table 1).

Examining different time periods: from 1990–2000, Xiongan's annual population growth rate was 0.7%, with Rongcheng County highest at 1% and Anxin County lowest at 0.5%, slightly below surrounding areas and below the Beijing-Tianjin-Hebei and national averages. From 2000–2010, Xiongan' s population grew more rapidly at an annual rate of 1.2%, exceeding surrounding areas, Hebei Province, and the national average, though still below Beijing and Tianjin. Xiongxian County showed the highest growth rate at 1.5%, while Rongcheng County was lowest at 0.8%. From 2010–2015, Xiongan' s annual growth rate was 0.9%, slightly above Hebei and national averages but far below Beijing and Tianjin, with Rongcheng County again lowest at 0.6%.

Temporally, Xiongan's population growth characteristics differ significantly from Beijing and Tianjin but resemble surrounding areas. In the 1950s, population growth was minimal at less than 2% increase. The 1960s entered a rapid growth phase with increases maintained between 2–4%. The 1970s–80s saw growth levels of 1–2%. Growth began slowing in the late 1990s, remaining below 1%. Since 2000, growth has slightly increased, maintaining 1–2%.

From 1990 to 2015, Xiongan's population increased from 530,000 to 1.13 million, adding 600,000 people (113.4% increase). The broader Xiongan-surrounding re-

gion grew from 3 million to 6.55 million, adding 3.55 million people (118.1% increase). The populations of Xiongan and its surrounding region grew essentially in tandem, though with internal regional variations. Compared with neighboring provinces and municipalities, Xiongan' s population increase was nearly 10 percentage points lower than Hebei (122.1%), far lower than Beijing' s 323.3% and Tianjin' s 234.7%, representing only one-third of Beijing' s increase and one-half of Tianjin' s (Figure 1 [Figure 1: see original paper]).

2.2 Population Density Characteristics

In 2015, Xiongan New Area's population density was 727 people/km^2, lower than the 768 people/km^2 in surrounding areas. Compared with neighboring provinces and municipalities, Xiongan-surrounding region' s density far exceeded Hebei' s 396 people/km^2 but was substantially lower than Beijing' s 1,323 people/km^2 and Tianjin's 1,298 people/km^2. In fact, although Xiongan's population density exceeds Hebei' s average, it has consistently remained below surrounding areas and far below Beijing and Tianjin.

Examining Xiongan's three constituent counties in 2015: Rongcheng County had a population density of 869 people/km^2, with Rongcheng Town being the most densely populated township, showing significant expansion of densely populated residential areas over the past 15 years. Xiongxian County had 763 people/km^2, with Xiongzhou Town as its most densely populated township, also showing expanded densely populated residential areas. Anxin County had 640 people/km^2, with Dazawang Town and Anxin Town being relatively dense, though expansion of densely populated areas has been less pronounced over the past 15 years.

3. Land Resource Carrying Capacity Based on Human-Grain Relationships

Land resource carrying capacity research centered on "population-grain"relationships addresses food security and cultivated land protection issues, forming an important foundation for regional land evaluation and planning [9]. This study employs land resource carrying capacity models , land resource carrying index evaluation models , and their assessment standards [9,10] to quantitatively evaluate and compare land resource carrying capacity in Xiongan and surrounding areas.

3.1 Temporal Variation in Land Resource Carrying Capacity (1985-2015)

From 1985 to 2015, land resource carrying capacity in Xiongan and surrounding areas showed fluctuating upward trends. Despite some decline in recent years, it remains at a relatively high level (Figure 3 [Figure 3: see original paper]). Specifically, from 1985–1998, Xiongan' s land resource carrying capacity rapidly increased from 463 people/km^2 to 1,055 people/km^2, then declined to 762 people/km^2 over the next four years. After 2003, carrying capacity began

recovering, peaking at 1,251 people/km^2 in 2011 before declining again, though the decrease has been relatively moderate, currently maintaining a high level above 1,000 people/km^2. Compared with neighboring provinces and municipalities, Xiongan-surrounding region' s land resource carrying capacity far exceeds the 300–500 people/km^2 range typical of the Beijing-Tianjin-Hebei region.

3.2 Land Resource Carrying Status

Over the past 30 years, the land resource carrying index in Xiongan and surrounding areas has remained stable at relatively low levels, with carrying status shifting from balanced-with-surplus to surplus, indicating substantially improved human-grain relationships (Figure 3 and Table 2). Since 1990, the carrying status transitioned from balanced-with-surplus to surplus, marking significant improvement in human-grain relations. Despite some annual fluctuations, the land resource carrying index has generally remained below 0.875, indicating a balanced-with-surplus status.

Xiongan New Area' s land resource carrying capacity is similar to surrounding areas and significantly higher than the Beijing-Tianjin-Hebei region. In 2015, Xiongan' s land resource carrying capacity was approximately 2.48 times the Beijing-Tianjin-Hebei average (Table 2). Unlike Beijing and Tianjin, where high urbanization has caused land overload and cross-regional occupation, Xiongan and surrounding areas maintain land carrying status that is not only better than Hebei' s critical balance but also superior to Beijing and Tianjin' s population overload (Figure 3 and Table 2), demonstrating harmonious human-grain relationships. However, as new area construction progresses, contradictions between basic farmland protection and construction land expansion, as well as cultivated land occupation, will become more prominent, requiring coordination of human-land relationships.

4. Water Resource Carrying Capacity Based on Human-Water Relationships

Water resource carrying capacity research centered on "population-water resources" relationships reveals the degree to which water resources can satisfy and guarantee regional population development [11]. This study employs water resource load index , human-water relationship based water resource carrying capacity , and water resource carrying index evaluation models and standards [10-13] to quantitatively assess water resource carrying capacity in Xiongan and surrounding areas under different hydrological year types. The study adopts three per capita water use standards: the current Beijing-Tianjin-Hebei level (230 m^3/person), the Beijing-Tianjin-Hebei planning level (350 m^3/person), and the national average (450 m^3/person) [2].

4.1 Water Resource Development and Utilization Status

Xiongan New Area exhibits high water resource development and utilization, slightly better than surrounding areas but with limited development potential. The water resource load index averages 85, reaching over 100 in Rongcheng County, indicating very high water resource utilization with limited development potential. Compared with surrounding areas, Xiongan' s water resource development is roughly equivalent to Hebei Province, lower than surrounding regions, but far better than Beijing and Tianjin (Figure 4 [Figure 4: see original paper]). The Beijing-Tianjin-Hebei region already has high water resource development; although Xiongan' s load index is lower than the Beijing-Tianjin-Hebei average, current development intensity is high with limited potential.

4.2 Water Resource Carrying Capacity Under Different Hydrological Conditions

From 2010–2015, Xiongan' s self-produced water resources ranged between 0.85–3.06 billion m^3, with substantial variation across hydrological year types and differing carrying capacities. Under low water demand scenarios (230 m^3/person), water resource carrying capacity in dry years (e.g., 2014) and normal years (e.g., 2015) was 238 people/km^2 and 438 people/km^2 respectively, while wet years (e.g., 2012) showed significantly improved capacity at 856 people/km^2 (Figure 5 [Figure 5: see original paper]). Overall, human-water relationships remain tense under different water supply and demand scenarios. Only in wet years under low and medium water demand scenarios can Xiongan' s water resource carrying index maintain 0.83 and 1.26 respectively, achieving human-water balance or balance-with-surplus. However, Xiongan' s water resource carrying capacity has never reached water surplus status, indicating a concerning human-water relationship.

Xiongan' s water resource carrying capacity is similar to surrounding areas. Based on 2012 wet year data, capacities were 856 people/km^2 and 860 people/km^2 respectively, better than Hebei' s 546 people/km^2 but lower than Beijing' s 1,046 people/km^2 and Tianjin' s 1,202 people/km^2 (Figure 5 and Table 3). However, considering regional water resource carrying status incorporating population scale, Xiongan and surrounding areas generally achieve human-water balance in wet years, with human-water relationships better than Beijing and Tianjin but worse than Hebei and the Beijing-Tianjin-Hebei average. Consequently, intra-basin water allocation and inter-basin water transfer have become necessary.

5. Recommendations for Promoting Coordinated Development

5.1 Prioritize Population Development Planning

As a "millennial project and national priority," Xiongan New Area requires rigorous and comprehensive planning. Population represents the most direct manifestation of regional development, making the guidance of rational population distribution and promotion of orderly population mobility urgent priorities in initial planning. Xiongan' s current population is 1.13 million, with plans to accommodate 2–2.5 million people in the long term, leaving approximately 1 million in growth potential and increasing population density to 1,500–1,600 people/km^2—higher than the current Beijing-Tianjin-Hebei average of 1,300 people/km^2. To prevent blind population flows and uncontrolled expansion, Xiongan should prioritize population development planning to address fundamental, long-term, and strategic questions such as "where will the population come from?" , "where will they go?" , and "in what form will they live?"

5.2 Enhance Land Resource Carrying Capacity Through Integrated Urban-Rural Planning

Land resource carrying capacity research based on human-grain relationships demonstrates that Xiongan' s land carrying capacity exceeds surrounding areas with harmonious human-grain relations and room for population agglomeration. However, absolute land resources are limited, with cultivated land accounting for three-fifths of the total area and low-lying land below 10 meters elevation comprising three-quarters of the territory, making integrated urban-rural planning essential. Xiongan' s construction must therefore: (1) effectively protect cultivated land within the planning area and intensify land use to improve comprehensive land production capacity; and (2) establish a unified land use and management system with surrounding areas, coordinating regional land use control and meeting future population development needs for grain and land through cross-regional cultivated land occupation and grain allocation.

5.3 Strengthen Water Resource Carrying Capacity Through Basin Water Allocation and Inter-Basin Transfer

Water resource carrying capacity research based on human-water relationships reveals that Xiongan' s water carrying capacity is inferior to surrounding areas, with limited development potential and tense human-water relations that cannot satisfy future population development and industrial agglomeration without intra-basin allocation and inter-basin transfer. We must recognize that the Daqing River Basin, where Xiongan is located, still has potential for water resource carrying capacity development, and spatial mismatches of wet, normal, and dry years within and between regions enable timely intra-basin water allocation. Additionally, existing inter-basin water transfer projects such as "Yueyue Jidian," "Huangye Jidian," and the South-to-North Water Diversion [14] have

become important supplements to Xiongan' s water supply. Establishing stable water transfer and allocation schemes and creating rational, unified regional water allocation and transfer mechanisms can effectively enhance water resource carrying capacity in the Baiyangdian Basin and safeguard Xiongan' s water security.

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Note: Figure translations are in progress. See original paper for figures.