Analysis of the Coordinated Development Mechanism Between Urbanization and Arable Land Resource Quantity Changes in Underdeveloped Mountainous Areas: A Case Study of Meizhou City

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Abstract: This study examines the urbanization level and changes in arable land resources in Meizhou City, Guangdong Province, from 1999 to 2020. It analyzes the coordination between urbanization and arable land resources, explores their interactive relationship, and investigates the impact of coordination on economic growth. The study employs entropy analysis and regression models to provide a scientific basis for achieving the coordinated development of urbanization and arable land resource protection in Meizhou City.

1 INTRODUCTION

Arable land resources are fundamental and crucial for human development, playing a vital role in the sustainable development of regional economies (Zhan, 2014). In China, as a populous country, achieving self-sufficiency in food is of utmost importance for ensuring stable development (He et al., 2018). Therefore, preserving arable land resources is significant (Cheng et al., 2022). Urbanization serves as a crucial indicator of a country's economic progress (Chan et al., 2023). Ensuring the harmonious development between urbanization and arable land resources becomes a driving force for sustainable development (Liu et al., 2022).

Meizhou City, as an underdeveloped mountainous region, should prioritize the implementation of the national policy of valuing and utilizing land and protecting arable land. It should transform land use patterns, allocate land resources efficiently, maintain a balance in the total amount of arable land, and facilitate the rapid development of various construction projects (Zhao et al., 2023; Zhang, 2019). This will maximize economic, social, and ecological benefits, achieving sustained and coordinated development within the local economy and society (Liang et al., 2019).

2 DATA AND METHODOLOGY

2.1 Study Area Introduction

Meizhou City is located in the northeastern part of Guangdong Province, China. It is a prefecture-level city situated at the intersection of Fujian, Guangdong, and Jiangxi provinces. Meizhou shares a border with Longyan and Zhangzhou in Fujian Province to the east and is adjacent to Chaozhou, Jieyang, and Shanwei in the south. It also connects with Heyuan in the west and Ganzhou City in Jiangxi Province to the north. Meizhou City holds the distinction of being a renowned national historical and cultural city, often referred to as the "hometown of culture" and "hometown of overseas Chinese." Geographically, Meizhou spans from 115°18′ to 116°56′ east longitude and 23°23′ to 24°56′ north latitude. It falls within the subtropical monsoon climate zone,

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characterized by high temperatures, significant temperature variations, ample sunshine, and concentrated rainfall. Traditional agriculture has long occupied a significant position in Meizhou's economy, with the primary sector playing a prominent role in its industrial structure. Compared to other cities in the province, Meizhou faces the challenges of a dense population and underdeveloped economy, placing it in the category of a poverty-stricken mountainous region.

The prominence of traditional agriculture in Meizhou's economy has initially mitigated the contradiction between land supply and demand for construction purposes. However, since 1995, the rapid socio-economic development of Meizhou has accentuated the imbalance between land supply and demand for construction purposes. Guangdong Province has set the goals of achieving modernization and a well-off society, thereby highlighting the urgent need for Meizhou to expedite its urbanization process while ensuring harmonious development between humans and the environment. Consequently, conducting an analysis of the patterns of urbanization development and arable land resource quantity changes in Meizhou City, and reflecting upon them, will facilitate the alleviation of the land supply-demand contradiction for construction purposes. This, in turn, will contribute to achieving sustainable development in society, population, resources, and the environment, while propelling Guangdong Province towards comprehensive modernization and the attainment of a well-off society.

2.2 Data Sources

To facilitate rigorous scientific research and ensure the smooth progression of the study, the data utilized in this paper primarily derives from authoritative sources such as the "*Meizhou Statistical Yearbook*", "*Guangdong Rural Statistical Yearbook*", "*Overall Planning of Meizhou City*", "*New Urbanization Planning of Meizhou City*" and "*Overall Planning of Meizhou City's Land and Space*".

2.3 Research Content and Methodology

The degree of coordination (C_{mn}) between changes in the amount of arable land resources and the level of urbanization is a quantitative description of the coupling degree between arable land carrying capacity and the level of urbanization in the study area. It is an important indicator for measuring the relationship between arable land resources and the

level of urbanization at different stages of urbanization development (Yu, 2019; Xu et al., 2023).

$$C_{mn} = (m + n) \Big/ \sqrt{m^2 + n^2} \quad (1)$$

In equation (1), m represents the rate of improvement in the level of urbanization in the study area during the urbanization process, n represents the rate of change in the amount of arable land resources in the study area during the urbanization process, and C_{mn} represents the degree of coordination between urbanization and arable land resources in the study area during the urbanization process, where $-1.414 \leq C_{mn} \leq 1.414$. Based on the variations in the values of m and n, a classification table of the degree of coordination between the level of urbanization and changes in the amount of arable land resources is constructed (Table 1).

Table 1: The coordination characteristics between the arable land resources change and urbanization level.

Level	C_{mn}	m,n	Type
I	$C_{mn} = 1.414$	m = n and m＞0, n＞0	Coordinated
II	$1.2 \leq C_{mn} < 1.414$	m≈n	More coordinated
III	$1.0 \leq C_{mn} < 1.2$	m＞0, n＜0 and m＞n	Basic coordination
IV	$0.8 \leq C_{mn} < 1.0$	m＞0, n＜0	Harmonious
V	$0.5 \leq C_{mn} < 0.8$	m＞0, n＜0	Harmonized
VI	$0 \leq C_{mn} < 0.5$	m＞0, n＜0	Barely harmonized
VII	$-1.414 \leq C_{mn} < 0$	m＞0, n＜0 or m＜0, n＜0	Not in tune

3 RESULTS AND ANALYSIS

3.1 Dynamics of Urbanization Development

During the study period, Meizhou City demonstrated relatively moderate fluctuations in its level of urbanization compared to other cities in the province, yet it consistently exhibited an upward trend (Figure 1). The urbanization level in Meizhou City increased from 23.25% at the beginning of the study period to 48.09% at the end, representing a substantial growth of 24.84% with an average annual increase of 0.83%. Specifically, the proportion of the urban population rose from 14.37% to 40.18%, indicating a remarkable

increase of 25.91% with an average annual growth of 0.86%. Moreover, the proportion of non-farm GDP (i.e., the contribution of the secondary and tertiary sectors to the total GDP) experienced a significant

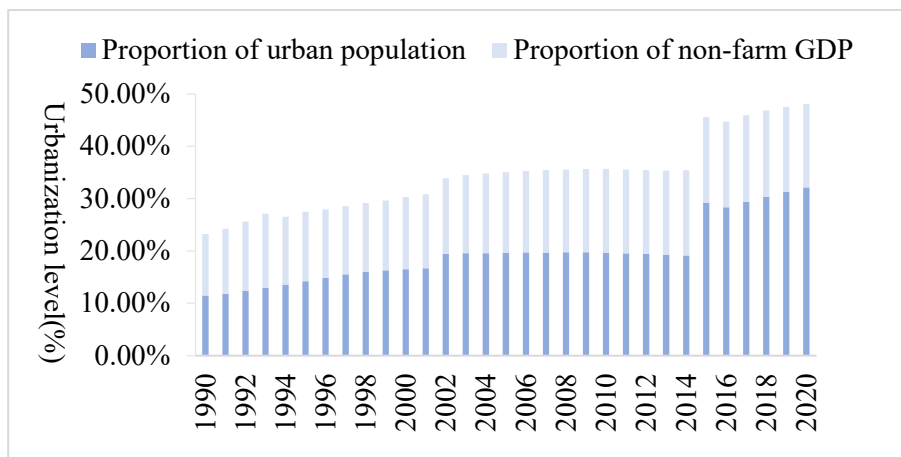rise from 58.75% to 79.72%, reflecting an impressive increase of 20.97% with an average annual growth of 0.70%.

Figure 1: The urbanization level changed status.

3.2 Development of Arable Land Resources

During the study period, the amount of arable land resources in Meizhou City exhibited distinct patterns divided into three phases (Figure 2), characterized by relatively stable and minor changes compared to other cities in the province. The first phase, spanning from 1990 to 1999, displayed a downward trend as the arable land area decreased from 1415.00 km^2 in 1990 to 1346.66 km^2 in 1999, resulting in a decline of 68.34 km^2 with an average annual decrease of 7.59 km^2. The second phase, covering the period from 2000 to 2020, witnessed a significant surge in arable land resources due to the adoption of a new statistical method for assessing arable land area in various cities across Guangdong Province. In 2000, the arable land area reached a peak of 1665.29 km^2. Subsequently, the amount of arable land resources in Meizhou City continued to experience a gradual upward trend, reaching 1682.66 km^2 in 2005. Within this phase, the increment amounted to 9.31 km^2, with an average annual increase of 1.86 km^2. The third phase, from 2006 to 2020, mirrored the characteristics of the first phase, displaying a gently declining trend as the arable land area decreased from 1675.45 km^2 to 1611.53 km^2. Consequently, the arable land resources witnessed a reduction of 63.92 km^2 with an average annual decrease of 4.57 km^2. The graphical representation reveals discernible fluctuations in the per capita arable land area in Meizhou City from 1990

to 2020, with the lowest point of 2.83 km² per 10,000 people observed in 1999 and the highest point of 3.43 km² per 10,000 people recorded in 2000.

3.3 Analysis of the Relationship between Urbanization Level and Changes in Arable Land Resources

3.3.1 Changes in Urbanization Level and Amount of Arable Land Resources

During the period from 1990 to 2020, Meizhou City experienced notable fluctuations in the quantity of arable land and the level of urbanization. The study period witnessed a substantial variation in arable land, with a change in the quantity of 196.53 km^2, corresponding to an annual change rate of 6.55 km^2, reflecting intensity of change of 13.89% and a dynamic attitude of 0.46%. The urbanization level exhibited a rise of 24.85% and an average annual growth rate of 0.83%. Furthermore, the urbanization occupancy factor in Meizhou City between 1990 and 2020 was determined as 7.91 km^2, indicating that each one-percentage-point increase in the urbanization level necessitated the utilization of 7.91 km^2 of arable land resources (Table 2). The findings from Table 2 underscore the significant changes in both arable land and urbanization levels during the period from 1990 to 2020, aligning with China's "8th Five-Year Plan" to "13th Five-Year Plan" periods.
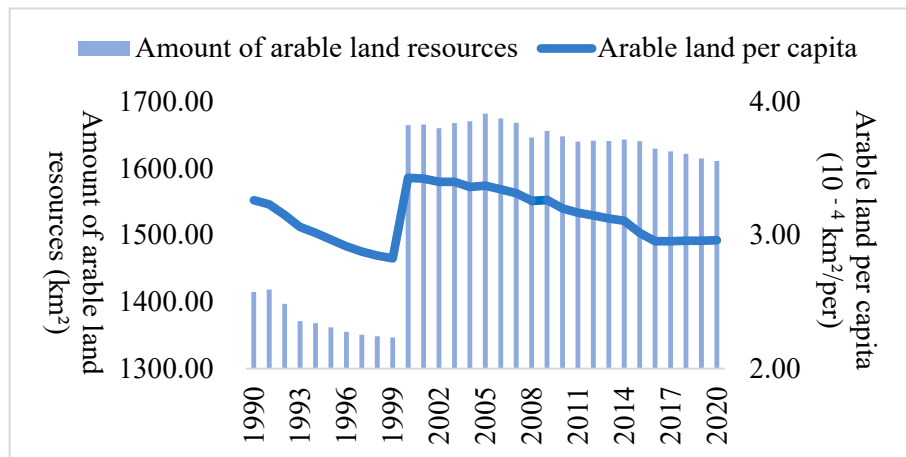
Figure 2: The arable land amount changed status.

Table 2: The Arable Land amount change status and urbanization evolution process.

	Amount of arable land resources				Urbanization level		
	Changes (km²)	Speed of change (km²/year)	The intensity of change(%)	Change of dynamic attitude(%)	Changes (%)	Average annual speed(%)	UOF* (km²)
The 8th Five-Year Plan	-56.69	-11.34	-4.00	-0.80	3.23	0.65	-17.54
The 9th Five-Year Plan	310.14	62.03	22.89	4.58	2.35	0.47	131.95
The 10th Five-Year Plan	16.37	3.27	0.98	0.20	4.21	0.84	3.89
The 11th Five-Year Plan	-26.97	-5.39	-1.61	-0.32	0.42	0.08	-64.29
The 12th Five-Year Plan	0.75	0.15	0.05	0.01	10.01	2.00	0.07
The 13th Five-Year Plan	-18.54	-3.71	-1.14	-0.23	3.39	0.68	-5.47
1990-2020	196.53	6.55	13.89	0.46	24.85	0.83	7.91

*Urbanization occupancy factor:The amount of arable land resources occupied in the process of urbanization.

3.3.2 Correlation between Urbanization Level and Amount of Arable Land Resources

To examine the coherence between the urbanization level and the amount of arable land resources in Meizhou City, a correlation analysis was conducted using the SPSS software, and a fitted curve graph was generated (Figure 3). The analysis revealed a correlation coefficient of 0.4121, indicating a moderate correlation between the urbanization level and the amount of arable land resources in Meizhou City. This finding highlights the need for further quantitative analysis to delve deeper into the relationship between these two factors.

3.3.3 Coherence between Urbanization Level and Amount of Arable Land Resources

From 1990 to 2020, Meizhou City witnessed significant fluctuations in the coherence between its urbanization level and the amount of arable land resources, displaying a pronounced tendency towards concentration. During the study period, 10 years exhibited a state of "Harmonized" or higher ($C_{mn} \geq$ 0.8), accounting for approximately 33.33% of the total years analyzed. Among these, 5 years (1991, 2003, 2004, 2005, 2014) were categorized as "More coordinated" ($1.2 \leq C_{mn} < 1.414$), and 3 years (2000, 2001, 2009) were classified as "Basically coordinated" ($1.0 \leq C_{mn} < 1.2$). The remaining 2 years (2002, 2015) fell into the "Harmonized" category ($0.8 \leq C_{mn} < 1.0$). Moreover, within the 12 years classified as "Not in tune" ($C_{mn} < 0$), a strong

continuous trend was observed during the periods of 1992-1996 and 2006-2013. In the remaining years, 3 years were deemed "Barely harmonized" ($0 \leq C_{mn} < 0.5$), while 5 years were considered "Basically harmonized" ($0.5 \leq C_{mn} < 0.8$). Overall, Meizhou City exhibited a relatively high coherence level in the early stages of the study period, followed by increased fluctuations and a distinctive pattern of periodic variations, reflecting a strong phase-aggregated characteristic (Figure 4).

By employing the coherence evaluation model for the urbanization level and the amount of arable land resources,

a comprehensive calculation and analysis of the coherence level between the urbanization level and the amount of arable land resources in Meizhou City from 1990 to 2020 were conducted, resulting in the coherence variation curve. The analysis indicates that as the urbanization process accelerates, the coherence between the urbanization level and the amount of arable land resources in Meizhou City experiences more frequent fluctuations, highlighting the urgent need for more comprehensive measures to promote their coordinated development.
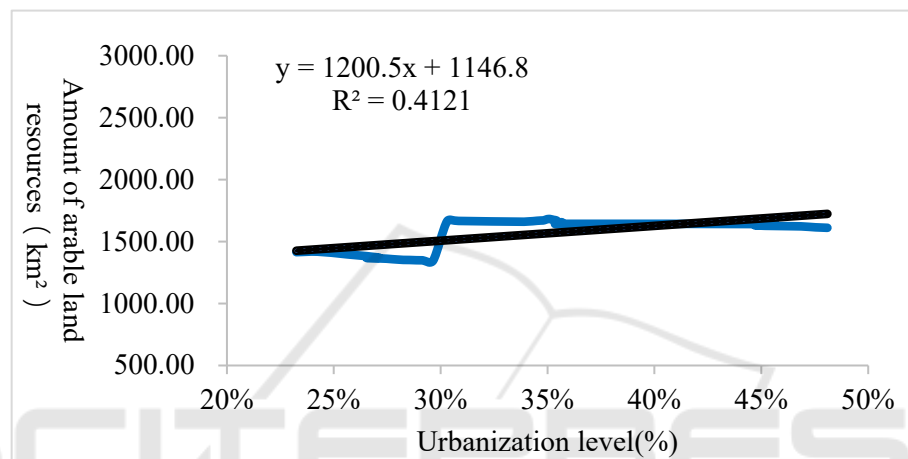

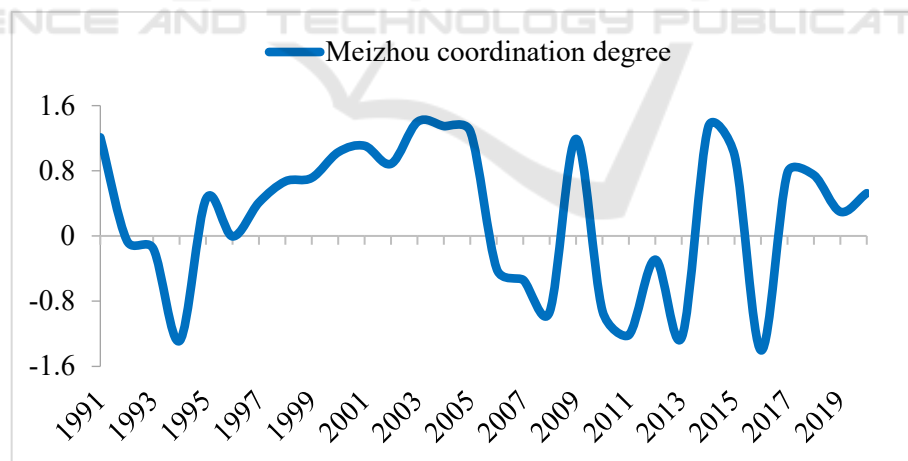Figure 3: The fitting curve of the Arable Land change and urbanization.

Figure 4: The coordination degree between the Arable land amount change and urbanization level.

4 CONCLUSIONS AND RECOMMENDATIONS

Based on the comprehensive analysis conducted, it is evident that the accelerated pace of urbanization in

Meizhou City has intensified the conflict between urban development and the preservation of arable land resources, leading to a significant supply-demand imbalance. To address these challenges effectively, the following recommendations are proposed:

a) Emphasize Sustainable Development: Meizhou City should prioritize sustainable approaches in urbanization endeavors, focusing on environmentally friendly practices and strategies. This includes promoting the optimization of construction land resources and encouraging their efficient and responsible use.

b) Enhance Land Intensity and Resource Efficiency: Measures should be taken to improve the intensity and efficiency of land utilization in Meizhou City. This can be achieved through the refinement and strict implementation of land-use standards, particularly for industrial land, along with effective management and planning practices.

c) Encourage Intensive Land Use Policies: Meizhou City should formulate and implement policies that incentivize and support the intensive use of land resources. This can involve providing incentives for enterprises to revitalize existing construction land resources and actively engage in sustainable land utilization practices.

d) Strengthen Land-Use Regulations: Rigorous enforcement of land-use regulations is essential to protect arable land in Meizhou City. It is imperative to establish and refine a comprehensive legal framework for land utilization, ensuring strict adherence to land-use purposes and the implementation of necessary safeguards to protect arable land.

e) Implement Dynamic Land Monitoring: Regular monitoring of land-use patterns is crucial for identifying and addressing issues such as inefficient land use and underutilization. Meizhou City should establish a robust system for dynamic land monitoring to detect and prevent such occurrences.

In summary, Meizhou City must prioritize sustainable and responsible urban development practices to effectively manage the conflict between urbanization and the preservation of arable land resources. By embracing sustainable development principles, optimizing land allocation, promoting efficient land use, and enforcing strict land-use regulations, Meizhou City can successfully tackle these challenges and achieve a harmonious balance between urbanization and the preservation of arable land resources.

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