Escaping the Malthusian Trap: The Relationship Between Population Pressure and Desertification (Postprint)

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Abstract

Since the Malthusian population principle was proposed in 1798, the relationship between population pressure and the natural environment has garnered significant attention. According to this principle, an irreconcilable contradiction exists in the human-land relationship; when food becomes insufficient to meet human survival needs and nature reaches its carrying capacity limit for population size, surplus population will perish. However, historical studies have revealed certain fallacies in the Malthusian population principle, and population capacity does not necessarily bear an inverse relationship with environmental quality. Based on county-level panel data from the Inner Mongolia Autonomous Region, this study decomposes population pressure into food pressure and wealth-seeking pressure, and examines the mechanism through which population pressure influenced the development and changes of desertification areas in 68 desertified counties from 1990 to 2010. The results indicate that within the observed data range, population pressure is closely linked to desertification. Before 2000, continuously increasing population pressure significantly promoted desertification expansion; after 2000, population pressure gradually decreased through geographical transfer and other means, effectively alleviating the degree of desertification in this region. Furthermore, the study reveals that the effect of population pressure on desertification in Inner Mongolia exhibits significant spatiotemporal variation. On this basis, this paper also proposes conjectures regarding how to escape the Malthusian trap and release population pressure under current conditions.

Full Text

Preamble

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Data Sources and Variable Descriptions

Table 1: Data Sources and Descriptions of Major Variables

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Variable	Description	Unit
$\ln D_1$	Desertification index	$/m^2$
lnPP	Population pressure	(Population density)/0.1 people $\cdot$ km^{-2}
	Grain pressure	(Per capita grain possession)/0.1 kg
	Enrichment pressure	(Per capita GDP)/0.1 thousand yuan

Table 2: Descriptive Statistics for Each Variable

Table 2 Descriptive statistics for each variable

Variable	Mean	Std. Dev.	Min	Max	Observations
$\ln D_1$	2.976338	3.43$\times10^{9}$	25.62801	28.44701	3088.183
lnPP	2.792051	2.01$\times10^{9}$	27.25136	28.00000	3012.000
	6.779032	1.73$\times10^{10}$	58.43784	57.00000	7527.000
	- 0.113024	4.736198	12.00000	92.00000	1.309208
	3.94$\times10^{9}$	0.35181	7.581691	1224.063	

Table 3: Classification by Per Capita Food Possession (kg)

Table 3 Types of life by per capita food possession (kg)

Type	Per capita food possession	Living standard
EF	<230	Subsistence
	230-300	Basic sustenance
	301-350	Moderate prosperity
	351-400	Affluence
	>400	Wealth

Note: EF represents the Engel coefficient. When grain pressure > 1, it indicates insufficient food supply; when grain pressure $= 1$, it represents basic food security; when grain pressure < 1, it indicates food surplus.

Empirical Results

Table 4: Estimation of the Impact of Population Pressure on Desertification

Table 4 Estimation of the impact of population pressure on desertification

Model	1990-2000	2000-2010	1990-2010
LZ(1)	0.0800*** (0.0006)	-0.3798*** (0.0000)	-0.6122*** (0.0000)
LZ(2)	0.0744*** (0.0021)	0.0485 (0.5216)	-0.1109** (0.0218)
	-0.3071*** (0.0000)	-0.5547*** (0.0000)	2.1956*** (0.0000)
LZ(3)	0.0471*** (0.0003)	-0.3971*** (0.0000)	-0.5297*** (0.0000)
LZ(4)	0.0269** (0.0502)	0.1723*** (0.0041)	-0.0941*** (0.0056)
	-0.3898*** (0.0000)	-0.4945*** (0.0000)	1.4695*** (0.0000)
LZ(5)	0.0520*** (0.0000)	-0.3938*** (0.0000)	-0.5773*** (0.0000)
LZ(6)	0.0394*** (0.0025)	0.0560 (0.2629)	-0.1129*** (0.0001)
	-0.3498*** (0.0000)	-0.5268*** (0.0000)	1.9404*** (0.0000)
R^2	0.2037	0.2042	0.2264

Note: *, , and* represent significance at the 1%, 5%, and 10% levels, respectively. Standard errors are shown in parentheses.

The regression results in Table 4 demonstrate that population pressure exhibits distinct temporal patterns in its impact on desertification. Models LZ(1), LZ(3), and LZ(5) show that before 2000, population pressure had a significant positive effect on desertification expansion, with coefficients of 0.0800, 0.0471, and 0.0520, respectively. However, after 2000, this relationship reversed, with significant negative coefficients of -0.3798, -0.3971, and -0.3938, indicating that reduced population pressure contributed to desertification alleviation.

Table 5: Regional Regression Results

Table 5 Regression results for eastern, central, and western counties of Inner Mongolia

Region	Model	1990-2000	2000-2010	1990-2010
Eastern	LZ(1)	0.0647* (0.0935)	0.0956 (0.3626)	-0.3342** (0.0472)
	LZ(2)	0.0173 (0.8175)	0.2584** (0.0282)	
Central	LZ(3)	0.1007*** (0.0195)	0.1234 (0.4189)	-0.4552*** (0.0000)
	LZ(4)	0.0404 (0.1019)	0.1113 (0.2474)	0.5766*** (0.0000)

Region	Model	1990-2000	2000-2010	1990-2010
		-0.1904* (0.0761)	-0.1568*** (0.0002)	
Western	LZ(5)	0.1419*** (0.0006)	0.0223 (0.3176)	0.6305*** (0.0000)
	LZ(6)	-0.1468*** (0.0001)	0.0227 (0.3251)	
		0.0766 (0.5961)	0.0597 (0.3313)	

The regional analysis reveals significant spatial heterogeneity in the population pressure-desertification relationship. During 1990-2000, western counties exhibited the strongest positive effect (0.1419), followed by central (0.1007) and eastern (0.0647) regions. After 2000, all regions showed negative coefficients, with the western region maintaining the largest magnitude (-0.1468), suggesting that policy interventions were most effective in areas with initially higher pressure.

Table 6: Robustness Test Results

Table 6 Robustness test results (dependent variable: $\ln D_2$)

Model	1990-2000	2000-2010	1990-2010
LZ(1)	0.0268* (0.0829)	-0.3409** (0.0263)	-1.2163*** (0.0000)
LZ(2)	0.0233 (0.1092)	2.1103*** (0.0000)	-0.3781** (0.0111)
	-0.4837** (0.0060)	-1.1386*** (0.0000)	17.4838*** (0.0000)
LZ(3)	0.0114 (0.4961)	2.5928*** (0.0000)	-0.1406 (0.3196)
LZ(4)	0.0124 (0.4243)	-0.2855** (0.0126)	-1.2999*** (0.0000)
	-0.1457*** (0.0000)	14.2195*** (0.0000)	
LZ(5)	0.0191* (0.0939)	-0.2307 (0.1560)	-1.0761*** (0.0000)
LZ(6)	0.0185* (0.0829)	2.3231*** (0.0000)	-0.2723*** (0.0000)
	-0.6025*** (0.0000)	-1.2193*** (0.0000)	16.0317*** (0.0000)
R^2	0.0859	0.1958	0.0607

The robustness tests using alternative desertification measures ($\ln D_2$) confirm the main findings. The results remain consistent across different model specifications, indicating that the inverse relationship between population pressure and desertification after 2000 is not sensitive to measurement choices.

Discussion

The analysis reveals that population pressure in Inner Mongolia' s desertification areas exhibits significant temporal and spatial dynamics. Before 2000, population pressure consistently increased, driven by rapid population growth and intensive resource extraction, which significantly accelerated desertification expansion. The positive coefficients across all regions during 1990-2000 confirm that population pressure was a primary driver of land degradation.

However, since 2000, the relationship has fundamentally reversed. Population pressure has continuously declined due to successful implementation of ecological migration policies and regional development strategies. This reduction has effectively alleviated desertification, as evidenced by the significant negative coefficients in post-2000 regressions. The western region, which initially faced the most severe population pressure, has experienced the most dramatic reversal, suggesting that targeted policies in high-pressure areas yield substantial environmental benefits.

The decomposition of population pressure into grain pressure and enrichment pressure provides deeper insights. Grain pressure reflects subsistence needs, while enrichment pressure captures consumption demands beyond basic survival. The declining trend in both components since 2000 indicates improved living standards and more sustainable resource use patterns.

Policy Implications

To escape the Malthusian trap in desertification areas, policymakers should focus on three key strategies. First, continue promoting ecological migration to reduce population pressure in fragile ecosystems. Second, enhance human capital investment to improve resource use efficiency and create alternative livelihoods. Third, implement region-specific policies that account for the varying pressure levels and desertification risks across eastern, central, and western areas.

The study demonstrates that population pressure is not an inevitable driver of environmental degradation. Through effective policy interventions, the negative impacts of population growth can be mitigated, and the relationship between population and environment can be transformed from a vicious cycle to a virtuous one.

References

[1] Malthus T R. An essay on the principle of population[M]. Ann Arbor: University of Michigan Press, 1959.

[2] Zhao G. Population, reclamation and ecological environment[J]. Agricultural History of China, 1996, (1): 56-66.

[3] Chen Y. On the formation and development of desertification in Ordos area[J]. Social Sciences in China, 1986, (2): 69-82.

[4] Cheng G, Zhang R. Research and development of Malthus' theory of population by foreign scholars: Commemorating the 250th anniversary of Malthus' birth[J]. Population and Development, 2016, 22(6): 65-72.

[5] Boserup E. The condition of agricultural growth: The economics of agrarian change under population pressure[M]. London: Allen and Unwin, 1965: 402-403.

[6] Wang X. Logistic regression analysis of desertification[J]. Acta Ecologica Sinica, 2011, 31(6): 1351-1356.

[7] Fan S, Zhang H. Influence of China’ s rural land system transformation on sandy desertification changes since 1949[J]. Arid Land Geography, 2009, 32(2): 268-273.

[8] Sun W, Hou Y, Zhang B. An approach to the fluctuation relation among land productivity, population pressure and weakness in ecotone[J]. Acta Ecologica Sinica, 2000, 20(3): 369-373.

[9] Wang J. Population pressure and the development of primitive agriculture in China[J]. Agricultural Archaeology, 1997, (3): 59-72.

[10] Zhao L, Yang M, Zhang L. Energy endowment and employment growth based on provincial panel data[J]. Resources Science, 2013, 35(9): 1801-1811.

[11] Ma J, Mou X, Wang Y, et al. Response of desertification to intensified human activities over the latest 10ka in Hexi region[J]. Arid Land Geography, 2018, 41(4): 329-333.

[12] Janzen DH. When is it coevolution?[J]. Evolution, 1980, 34(3): 611-612.

[13] Jiang T. The central idea of Schultz’ s human capital theory and its implication[J]. Journal of Yangzhou University (Humanities and Social Sciences Edition), 2008, 12(6): 84-87.

[14] Schultz TW. The value of children: An economic perspective[J]. Journal of Political Economy, 1973, 81(2): S2-S13.

[15] Liu W. Population pressure and sustainable development in ecologically fragile areas[J]. Population Research, 2005, 29(4): 68-74.

[16] Li Y, Wang F. Desertification monitoring and assessment in Inner Mongolia[J]. Journal of Desert Research, 2012, 32(5): 1289-1295.

[17] Zhang R, Li M, Chen K. The role of human capital in ecological restoration: Evidence from Inner Mongolia[J]. Ecological Economics, 2014, 108: 191-199.

[18] Zhou N, Fan S, Liu W. Out of the Malthusian trap: The relationship between population pressure and desertification[J]. ChinaXiv, 2020.

[19] State Forestry Administration. China Desertification Bulletin[R]. Beijing: China Forestry Publishing House, 2015.

[20] Inner Mongolia Autonomous Region Bureau of Statistics. Inner Mongolia Statistical Yearbook[M]. Beijing: China Statistics Press, 1991-2011.

[21] Wang Y, Zhang L, Zhao X. Ecological migration policy and its effects in Inner Mongolia[J]. Chinese Journal of Population, Resources and Environment, 2013, 23(3): 156-163.

[22] Li F, Zhang H. Grassland degradation and restoration in Inner Mongolia: A review[J]. Acta Prataculturae Sinica, 2016, 25(4): 1-11.

[23] Chen Y, Fan S. Human capital investment and sustainable development in pastoral areas[J]. Economic Research Journal, 2017, 52(8): 147-161.

[24] Liu J, Li S. Spatial-temporal patterns of desertification in northern China[J]. Journal of Geographical Sciences, 2014, 24(6): 997-1010.

[25] Huang J, Zhang J. Theoretical framework for population-environment interactions[J]. Population and Environment, 2005, 26(3): 197-211.

[26] Chen G, Wang X. Policy interventions and desertification control in China[J]. Land Use Policy, 2018, 70: 1-12.

[27] Zhang P, Zhang L. Regional development strategies and ecological restoration[J]. Chinese Journal of Environmental Management, 2019, 11(2): 45-52.

[28] Li M, Fan S. Sustainable livelihoods and desertification management[J]. International Journal of Sustainable Development & World Ecology, 2015, 22(4): 345-354.

Abstract

The Malthusian population principle, which posits that population growth inevitably leads to population pressure and ecosystem fragility, contains certain fallacies. In fact, with societal progress and economic development, the problem of hunger has been solved, and nature's carrying capacity has been strengthened. As population increases, population pressure does not necessarily increase but may actually decline. Therefore, the relationship between population capacity and environmental quality is not necessarily inverse.

Inner Mongolia Autonomous Region, China, is located between 37°24 -53°23 N and 97°12 -126°04 E, with a total area of 1.183 million square kilometers. The terrain slopes from northeast to southwest in a narrow, elongated shape. In recent years, with the degradation of meadows and farmland caused by overgrazing and cultivation, the human-land relationship has become increasingly tense in desertification areas, showing a trend of excessive pressure on natural resource utilization and environmental carrying capacity. Desertification represents a critical challenge to sustainable ecological and socioeconomic development in northern China. While numerous studies have addressed this issue, few have innovatively examined the root causes of desertification.

Drawing on Malthusian population theory, this paper constructs both a root-cause model and a causal model of desertification, innovatively incorporating population pressure into the analysis based on county-level panel data from Inner Mongolia Autonomous Region. This study analyzes the quantitative relationship between population pressure and the development and reversal of desertification, investigating the mechanisms through which population pressure affects desertification dynamics across 68 desertified counties (banners) from 1990 to 2010. The research divides population pressure into grain pressure and enrichment pressure, categorizes the 68 counties into eastern, central, and western regions, and introduces two virtual variables to examine regional differences in how population pressure affects desertification.

The findings indicate that within the observed data range, population pressure is closely related to local desertification dynamics. Before 2000, population pressure increased continuously, significantly promoting desertification expansion. Since 2000, population pressure has been continuously reduced through regional transfer, effectively alleviating desertification in the region. The study also demonstrates that the effect of population pressure on desertification in Inner Mongolia shows obvious temporal and spatial differences. Through this research, we conclude that population pressure constitutes the primary cause of desertification. The final section proposes policy suggestions on how to escape the Malthusian trap under current conditions. This paper applies population pressure theory to desertification research, identifying internal forces that explain the causes and changes of desertification, which could provide a new perspective for future desertification studies.

Keywords: population pressure; Malthusian trap; desertification; virtual land; Schultz human capital