A Geographical Analysis of Population Pressure and Food Security in Karnataka: Using Malthusian and Boserup Theories

Naik Rohit[1] & Dr. L.T Nayak[2]

Karnatak University, Dharwad

Corresponding Author – Naik Rohit

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Introduction:

The relationship between population growth and food supply has long been debated in development and environmental studies. Thomas Robert Malthus (1798) argued that population increases geometrically while food production grows only arithmetically, leading to inevitable scarcity and crisis. In contrast, Ester Boserup's (1965) challenged this pessimistic view, proposing that population pressure acts as a stimulus for agricultural innovation and technological advancement. According to Boserup, necessity drives intensification, farmers respond to growing population density by adopting improved methods and that what happened in case of Karnataka over the three decades, investing in irrigation, fertilizers, and new crop varieties. Together, these two perspectives define the classical tension between "Malthusian constraint" and "Boserupian adaptability."

Over the three decades from 1991 to 2021, Karnataka's population raised from about 45 million to 71 million an increase of roughly 58 per cent. During the same period, food grain production expanded from 6.8 million tonnes to about 25 million tonnes, representing a rise of 266 per cent. These figures suggest that agricultural output has not only kept pace with demographic growth but has outstripped it, suggesting strong evidence of Boserupian adaptability at the state level. Yet significant spatial variations persist, reflecting the influence of irrigation networks, input use, and climatic stress across districts. This paper therefore examines Karnataka's population food relationship through a spatial and temporal picture , applying elasticity (β) analysis to measure how food grain availability has responded to demographic change. The analysis integrates district level data on population, food grain production, rainfall, and temperature from 1991 and 2021. Instead of presenting extensive tabular data, the study employs graphical interpretation of β trends to distinguish areas of Malthusian pressure ($\beta < 1$) from those of Boserupian adaptability ($\beta \geq 1$). By combining classical theory with empirical evidence, this research aims to contribute to the broader understanding of how population pressure, technological change, and climatic variability jointly shape food security outcomes in Karnataka.

Study Area:

Karnataka is the sixth largest state in India by area and the ninth most populous in India. It is situated in the western part of the Deccan peninsular India with a geographical area of 1, 19,791 sq. km, which accounts for 5.84 per cent of the total area of the country. The territorial limit of the study area lies between 11–31° North latitudes to 18–45° North latitudes and 74°–12′ East to 78–40° East longitudes. The study region is bounded by the Arabian Sea and Goa State on

the west and by Tamil Nadu and Kerala on the south-west and south respectively; Maharashtra State on the north, Telangana in the north-east, and Andhra Pradesh on the east. The area under study consists of 31 districts, 237 talukas, 254 urban centres, and 27,683 inhabitations. According to the 2001 census the total population was 5.28 crores, which contributed 5.05 per cent of the total population of India. Karnataka experiences four seasons: the winter in January and February is followed by summer between March and May, the monsoon season between June and September, and the post-monsoon season from October till December.

Meteorologically, Karnataka is divided into three zones—coastal, north interior, and south interior. Of these, the coastal zone receives the heaviest rainfall with an average of about 3,638.5 mm (143 in) per annum, far in excess of the state average of 1,139 mm (45 in). Amagaon in Khanapura taluka of Belagavi district received 10,068 mm (396 in) of rainfall in 2010. In 2014, Kokalli in Sirsi taluka of Uttara Kannada district received 8,746 mm (344 in) of rainfall. Agumbe in Thirthahalli taluka and Hulikal of Hosanagara taluka in Shivamogga district were among the rainiest places in Karnataka, situated in one of the wettest regions in the world.

Objectives:

The main objectives of the present investigation are:

1. To evaluate the relationship between population growth and food grain availability in Karnataka for two point of time i.e. 1991 and 2021.
2. To study the spatial distribution of population pressure and food availability using Malthusian and Boserupian elasticity (β) concept.
3. To examine the role of agricultural intensification (irrigation, fertilizer use) in shaping food security outcomes.
4. To compare the outcome of population growth and food production obtained by Malthusian trap or Boserupian adaptability.

Hypotheses:

- Districts with higher population growth tend to experience Malthusian trap ($\beta < 1$).
- Districts with significant agricultural intensification (irrigation, fertilizer use) will show Boserupian adaptability ($\beta \geq 1$).

Data Base and Methodology:

The present study relies on secondary data compiled from authorities of government and international statistical agencies. The temporal coverage spans two time period 1991, and 2021, representing benchmark years for analysis. Population statistics, including literacy rates, sex ratios and urban–rural distribution, were obtained from the Census of India, District-wise agricultural statistics such as food grain production, fertilizer consumption, irrigation coverage and livestock data were sourced from Karnataka at Glance, Government of Karnataka. Climate-related data, including rainfall and minimum and maximum temperature (T2M), were obtained from the satellite-derived datasets from the NASA POWER Data Portal, Health, nutrition and female literacy data were collected from the National Family Health Surveys (NFHS-2, NFHS-3, NFHS-4 and NFHS-5). Finally, global standards and comparative frameworks for food security were referenced from the Food and Agriculture Organization (FAO) Statistical Yearbooks. The key measure used is elasticity (β): $\beta = (\ln(F_t) - \ln(F_0)) / (\ln(P_t) - \ln(P_0))$.

Techniques Implied:

In the present investigation Elasticity analysis, Bosarupian adoptability, and Malthusian trap and suitable cartographic methods have been implied. These approaches enable the systematic examination of the relationship between population growth and food grain availability in Karnataka between 1991 and 2021, while situating the analysis within Malthusian and Boserupian frameworks.

1. Elasticity (β) Analysis:

The primary quantitative technique applied in this paper is elasticity (β) analysis, which assesses the responsiveness of food grain growth relative to population growth. The formula is expressed as
$$\beta = (\ln(F_t) - \ln(F_0)) / (\ln(P_t) - \ln(P_0))$$
where F denotes food grain availability and P denotes population. A value of $\beta \geq 1$ denotes Boserupian adaptability, implying that food supply has increased more rapidly than population, while $\beta < 1$ denotes Malthusian pressure, where food availability lags behind population growth. If $\beta \geq 1$, food grew proportionally faster than population (Boserupian adaptability). If $\beta < 1$, food lagged population (Malthusian pressure). Aggregate and district-level β values were derived from 1991 and 2021 data. This technique provided the foundation for classifying districts and for understanding the macro-level trajectory of Karnataka.

2. Graphical and Trend Analysis:

Graphical analysis was employed to visually interpret trends in population and food grain growth. Figures included:

- Distribution of elasticity (β) across districts.
- Comparative graphs of population versus food grain production (1991–2021).
- Long-term trends in both population and food grain output.
- Per capita food grain availability trajectories.

Results and Discussion:

Trend in Population growth and food availability:

At the state level, Karnataka's population increased from about 45 million in 1991 to over 71 million in 2021, an increase of 58 per cent. During the same period, foodgrain production rose from 6.8 million tonnes to over 25 million tonnes, a net increase of 266 per cent. This surge ensured that per capita foodgrain availability more than doubled, from roughly 152 kg per person per year in 1991 to about 352 kg in 2021. It is worth noting that this result clearly contradicts the Malthusian expectation of declining per capita resources. Fig. 1 shows that while population increased by about 58 per cent, food grain production increased by over 260 per cent. This disproves the Malthusian prediction of per capita decline and instead supports Boserup's claim that population growth drives intensification and innovation. Fig. 2 shows that while the population steadily increased from about 45 million in 1991 to over 71 million in 2021, food grain production rose much faster from 6.8 million tonnes to more than 25 million tonnes. This divergence highlights the Boserupian pathway, as production accelerated disproportionately compared to demographic growth. Fig. 3 reveals that per capita food grain availability more than doubled over three decades, rising from ~152 kg/year in 1991 to ~352 kg/year in 2021. This directly contradicts Malthus's prediction of diminishing per capita subsistence and instead supports Boserup's argument that population growth induces technological and agronomic change to expand carrying capacity.
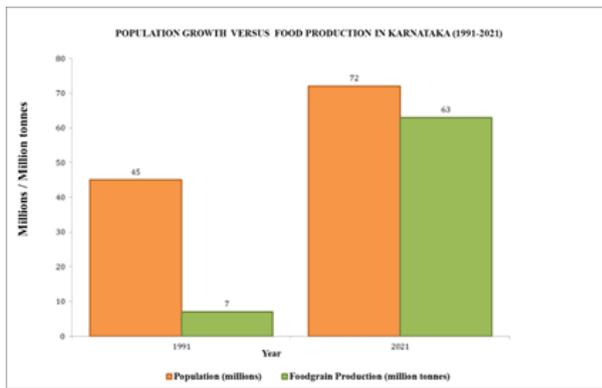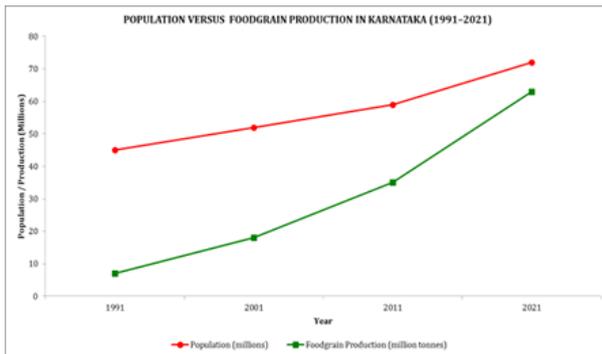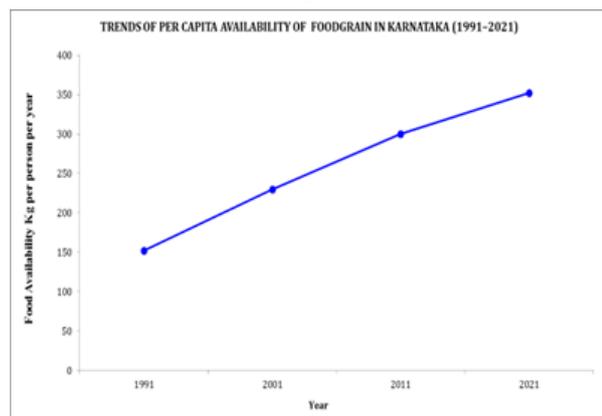
Fig. 1.

Fig.2

Fig.3

Population pressure and food availability Elasticity:

Malthusian trap and Boserupian Adoptability norms, the elasticity (β) values reflect this state-level resilience. The aggregate β for Karnataka stands above 1.5, indicating that foodgrain production grew one and a half times faster than population (Fig.4). This is a decisive sign of Boserupian adaptability. The steep rise between 2006 and 2021 coincided with major irrigation expansion (Upper Krishna, Tungabhadra projects) and higher input use,

demonstrating how infrastructure and policy amplified Boserup's innovation pathway.

Despite this broad success, district variation persists. While most districts surpassed the β ≥ 1 threshold, Dakshina Kannada and Kodagu fell behind, showing local Malthusian tendencies. These two regions, constrained by hilly terrain and crop diversification away from cereals, highlight how ecological limits shape outcomes. By contrast, districts in northern Karnataka such as Bagalkot and Belagavi, with extensive irrigation, recorded β values exceeding 2.5, confirming that population pressure, when supported by inputs, can drive remarkable agricultural growth. In sum, the state-level scenario shows Boserupian adaptability prevailing across Karnataka, while local ecological and economic contexts determine whether Malthusian pressure emerges in specific pockets. Figure:4 illustrates that the vast majority of districts lie to the right of the β=1 threshold, confirming Boserupian adaptability. Only Dakshina Kannada and Kodagu fall below the line, showing Malthusian pressure, largely due to geographic constraints and crop diversification.
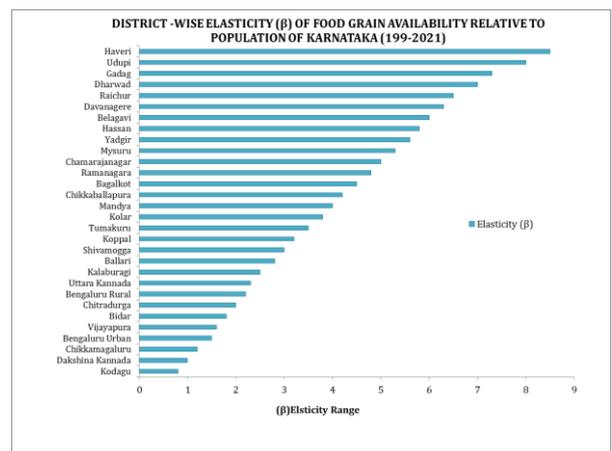
Discussion:

To understand population growth and food availability, it is important to interpret the results within the framework of both Malthusian and Boserupian theories. The below explained

discussion would give clear picture regarding the subject.

Spatial pattern of Malthusian trap and Boserupian adoptability:

Areas with Malthusian trap: (β) Beta <1

According to Thomas Malthus's classical theory (1798), when population increases faster than food production, the result is a Malthusian trap a situation where per capita food availability declines, eventually constraining human welfare. Malthus's framework, however, was primarily concerned with subsistence food grains and did not account for modern diversification into commercial crops or external food trade

The elasticity analysis for study area reveals important spatial variations in the relationship between population growth and food grain production. Out of all the districts, only Dakshin Kannada and Kodagu show evidence of being in a Malthusian trap, with elasticity values of 0.98 and 0.80 respectively. This means that in these two districts, the growth of food grain production has been slower than the growth of population over the study period (1991–2021). However, it is crucial to note that the shortfall in elasticity does not necessarily indicate food scarcity in the traditional sense. Rather, it reflects the geographical and economic structure of these districts. Both Dakshin Kannada and Kodagu are coastal and hilly regions, where physical terrain limits extensive cultivation of food grains. Instead, their local economies rely heavily on fishing, plantation crops (such as coffee, pepper, and areca nut), and other region-specific dietary practices. These conditions naturally reduce the proportion of land under food grains, even as the population continues to rise.

Areas of Non-Malthusian trap: (β) Beta >1:

In this category districts are those who have crossed the beta threshold of 1oe above one. This category of district is exact opposite to the

above category. Here in these districts population might have grown much but food production outpaced the population numbers/growth. Out of thirty districts twenty eight are comes under Non-Malthusian trap. Some districts have very large population still scored good beta index in elasticity e.g. Bengaluru Urban and Belagavi scored 2.6 and 6.6 in elasticity index respectively. Here in these districts production growth have been fueled with the help irrigation, fertilizer consumption and other factors.

To understand the spatial pattern of Boserupian adoptability, results of the area under study has been classified into two groups such as 1) area with adoptability and 2) areas of non adoptability

Areas with Boserupian adoptability: (β) Beta >1:

Boserup's Adaptability, proposed by Ester Boserup, presents an optimistic view of the relationship between population growth and agricultural development. It argues that when population pressure increases, societies do not collapse (as Malthus suggested) but rather adapt through innovation, technological advancement, and better resource management. According to this view, population growth acts as a positive force that pushes humans to find new ways to produce more food and improve productivity

In clear contrast, most parts of Karnataka showed Boserup's adaptability where agriculture improved to meet population growth. In 28 out of 30 districts, the elasticity (β) of food grain production compared to population was 1 or more, meaning food production grew as fast as, or faster than, the population. Overall, Karnataka's population rose by about 58% (from nearly 45 million in 1991 to 71 million in 2021), but food grain production increased by around 266% (from 6.8 million tonnes to 25 million tonnes). Because of this, the per person food grain availability more

than doubled from about 152 kg per year in 1991 to 352 kg in 2021.

Districts located in the Krishna and Tungabhadra river basins like Bagalkot, Belagavi, Ballari, and Raichur — showed very high β values (above 2.5). This means their food production increased much faster than their population. The main reasons were better irrigation facilities (new dams and canal systems), more fertilizer use, and the spread of high-yield crop varieties from the Green Revolution. These changes made agriculture more intensive and productive, which is exactly what Boserup's theory says that when population pressure increases, farmers innovate and improve productivity.

So, the general trend across Karnataka clearly supports Boserup's idea that "necessity drives innovation." The pressure from rising

population led to better and more efficient farming, which resulted in a big improvement in overall food availability.

Areas without Boserupian adoptability: (β) Beta <1

Boserup's Adoptability is areas where agricultural reforms, farmer's education, innovation in farming, and technological or scientific use etc. which most of the districts were adopted. Only two districts weren't able to adopt these things which very less number, only two districts have contradicted Boserup's Adoptability which are Dakshin Kannada and Kodagu. These districts are mainly falls under coastal and hilly Malnad region which now for its plantation and commercial crops and they have dietary system which mainly contains fish and locally grown things

Spatial pattern of Malthusian trap and Boserupian adoptability:
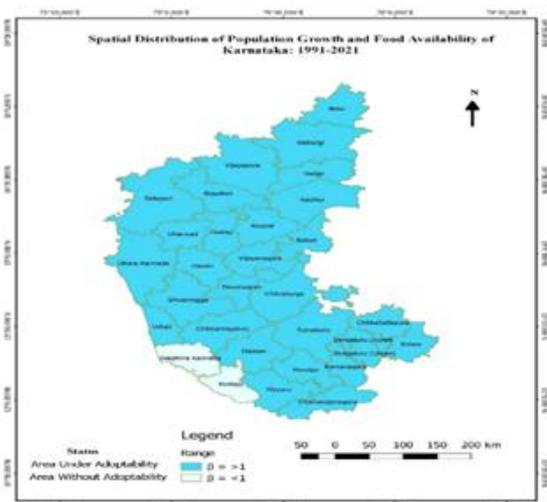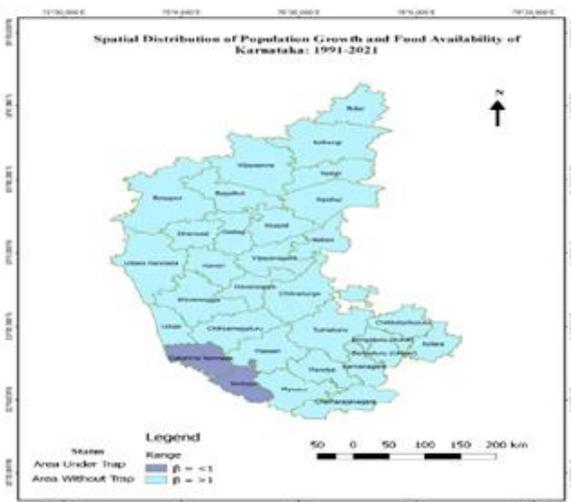
Conclusion:

This study of Karnataka's 30 districts from 1991–2021 demonstrates that Boserupian adaptability dominates, with 28 districts recording elasticity (β) ≥ 1. Foodgrain availability grew proportionally faster than population, ensuring improved per capita availability. At the same

time, two districts—Dakshina Kannada and Kodagu—exhibited Malthusian pressure, highlighting localized traps shaped by ecological constraints and land-use shifts. Thus, while Karnataka as a whole overcame the classical Malthusian trap, the theory still offers valuable insight into regions with stagnant or declining

food grain production. The balance of evidence therefore shows that Boserup's optimism about induced innovation largely prevailed in this context, though Malthus's warning persists in pockets where natural and socio-economic limits restrict adaptability. Policy implications include continued investment in irrigation, sustainable intensification, and targeted interventions in vulnerable districts.

References:
1. Bhattacharya, H., & Innes, R. (2006). Malthus vs. Boserup: An empirical exploration of the population–environment nexus in India. SSRN Working Paper.
2. Boserup, E. (1965). The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. London: Allen & Unwin.
3. Crist, E., Mora, C., & Engelman, R. (2017). The interaction of human population, food production, and biodiversity protection. Science, 356(6335), 260–264.
4. Cuffaro, N. (1997). Population growth and agriculture in poor countries. World Development, 25(7), 1151–1167.
5. Government of Karnataka. (1991–2021). District at a Glance. Directorate of Economics and Statistics, Bengaluru.
6. Government of Karnataka. (1991–2021). District Statistical Handbooks. Directorate of Economics and Statistics, Bengaluru.
7. Jana, A., & Goli, S. (2024). Gazing at long-term linkages between agricultural land use and population growth in India: An inverted U-shape relationship. Journal of Demographic Economics.
8. Lemmen, C. (2011). Malthusian assumptions, Boserupian response in models of the transitions to agriculture. arXiv preprint arXiv:1108.2585.
9. Malthus, T. R. (1798). An Essay on the Principle of Population. London: J. Johnson.
10. Miladinov, G., et al. (2023). Impacts of population growth and economic development on undernourishment: Causal evidence from low- and middle-income countries. Frontiers in Human Dynamics, 5, 1121662.
11. Pooley, G. L. (2023). Malthus Had It Backwards: Resources grow much faster than population if people are free to innovate. HumanProgress, 12 April 2023.
12. Turner, B. L. (2010). Ester Boserup: An interdisciplinary visionary relevant for today. Proceedings of the National Academy of Sciences, 107(51), 21963–21965.