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Population growth and regional food security dynamics: evidence from the food security index in Gorontalo Province, Indonesia (2018–2024)

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Abstract

Food security remains a critical component of sustainable regional development, particularly in agrarian areas experiencing ongoing demographic change. Population growth increases food demand and may exert pressure on food systems if not matched by adequate improvements in food availability and access. This study aims to analyze the effect of population growth on the Food Security Index in Gorontalo Province, Indonesia, during the period 2018–2024, with a focus on understanding the demographic dimension of food security at the subnational level. The study employs a quantitative explanatory approach using panel data at the regency and city level. Secondary data on population growth are obtained from official statistical sources, while food security is measured using the Food Security Index, a composite indicator reflecting food availability, access, and utilization. Linear panel regression analysis is applied to estimate the relationship between population growth and food security over time. The results indicate that population growth has a statistically significant and negative effect on the Food Security Index in Gorontalo Province. This finding suggests that increases in population tend to weaken food security when growth in food system capacity does not keep pace with rising demand. The discussion highlights that population growth affects food security through multiple channels, including pressure on food availability, competition for agricultural land, and reduced economic access to food for vulnerable households. These outcomes are consistent with demographic and entitlement-based perspectives, emphasizing that food insecurity arises not only from supply constraints but also from limitations in access and utilization. In conclusion, the study demonstrates that population growth constitutes an important determinant of regional food security in Gorontalo Province. The findings underscore the need for food security policies that integrate demographic considerations alongside agricultural development and social protection measures to ensure sustainable and equitable food security outcomes.

Keywords: Population Dynamics; Regional Food Security; Demographic Pressure

1. Introduction

Food security has long been recognized as a fundamental pillar of sustainable development, closely linked to human welfare, economic stability, and social cohesion. It encompasses not only the availability of sufficient food supplies but also people's ability to access, utilize, and sustainably maintain adequate and nutritious food over time. In the global development agenda, food security occupies a central position, as reflected in the Sustainable Development Goals (SDGs), particularly Goal 2, which aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. For developing regions, food security is especially critical because disruptions in food systems can quickly translate into rising poverty, malnutrition, social unrest, and economic instability. Consequently, understanding the drivers of food security at the regional level remains an important scholarly and policy concern.

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Recent literature emphasizes that food security is inherently multidimensional and influenced by complex interactions among demographic, economic, social, and environmental factors. The Food and Agriculture Organization (FAO) conceptualizes food security around four key dimensions: availability, access, utilization, and stability (FAO, 1996). Empirical studies increasingly show that improvements in food production alone are insufficient to guarantee food security outcomes if demographic pressures and socioeconomic inequalities are not adequately addressed (Kristiawan, 2020; Wehantouw et al., 2021). In many regions, rapid population growth continues to exert pressure on food systems by increasing demand, intensifying competition over land and resources, and amplifying vulnerabilities among low-income households. These challenges underscore the importance of examining demographic dynamics, particularly population growth, as a critical determinant of food security at the subnational level.

In the Indonesian context, food security has been positioned as a strategic national priority, supported by a comprehensive policy framework and institutional arrangements. However, substantial disparities persist across provinces and districts, reflecting uneven development trajectories and localized constraints. Provincial-level analyses reveal that regions with strong agricultural sectors do not necessarily achieve higher food security outcomes, suggesting the presence of structural and demographic factors that mediate the relationship between production capacity and food security performance (Rikastya, 2022). This phenomenon is particularly relevant for agrarian regions where agricultural output is relatively high but food security indicators remain uneven across administrative areas.

One of the most salient challenges affecting food security in such regions is population growth. Classical demographic theory, most notably Thomas Robert Malthus's argument, posits that population growth tends to increase at a faster rate than food production, potentially leading to shortages and heightened food insecurity if not counterbalanced by technological progress or structural change (Pieris, 2015). While contemporary scholars have nuanced this perspective, there remains broad agreement that rapid or poorly managed population growth can place significant stress on food systems, especially in regions with limited land availability, low productivity, or persistent poverty. Population growth not only raises aggregate food demand but also contributes to land conversion, urban expansion, and increased pressure on public infrastructure, all of which may undermine local food availability and access.

From a policy perspective, strengthening food security under conditions of population growth requires integrated and evidence-based approaches. At the macro level, governments seek to stabilize food supply through domestic production, trade, and stock management, while at the micro level, interventions focus on improving household access and nutritional outcomes. According to the National Food Agency, food security policies aim to ensure adequate supply, stabilize availability and access at both macro and micro levels, improve food quality and consumption, and strengthen supporting infrastructure. Nevertheless, these policy efforts often face limitations when demographic pressures outpace the capacity of food systems to adapt. As a result, understanding the magnitude and direction of the relationship between population growth and food security becomes essential for designing effective and targeted interventions.

Previous studies have proposed several general solutions to mitigate the adverse effects of population growth on food security. These include increasing agricultural productivity through technological innovation, promoting food diversification, improving distribution systems, and strengthening social protection mechanisms for vulnerable populations (Kristiawan, 2020; FAO, 2015). While such strategies are widely endorsed, their effectiveness varies significantly across regions depending on local demographic trends, institutional capacity, and resource endowments. In many developing regions, productivity gains are constrained by limited access to capital, technology, and infrastructure, making it difficult to fully offset the growing food demand associated with population increase.

A substantial body of empirical research has specifically examined the relationship between population growth and food security using different methodological approaches. Studies conducted at both national and regional levels generally find that population growth exerts a negative influence on food security indicators when not accompanied by proportional increases in food production or income (Wehantouw et al., 2021; Sukamdi and Partiwi, 2010). Time-series and panel data analyses further suggest that demographic pressure can weaken food availability and access, particularly in regions characterized by smallholder agriculture and limited land expansion opportunities (Nnamani and Ugwu, 2020; Hanafy, 2018). These findings lend empirical support to the theoretical expectation that population dynamics play a crucial role in shaping food security outcomes.

In addition to availability-related effects, the literature also highlights the importance of access and entitlement mechanisms in mediating the population–food security relationship. Amartya Sen's Entitlement Theory challenges the notion that food insecurity arises solely from insufficient supply, emphasizing instead the role of economic and social access to food (Sen, 1981). From this perspective, population growth may exacerbate food insecurity not only by increasing demand but also by intensifying competition in labor markets, suppressing wages, and reducing household purchasing power, particularly among the poor. Empirical studies in various developing regions confirm that population

pressure often interacts with poverty and inequality to produce adverse food security outcomes, even in contexts where aggregate food availability remains adequate.

Despite the growing body of literature, several gaps remain, particularly at the subnational level in Indonesia. Many existing studies focus on household-level food security or rely on single indicators such as rice availability, consumption, or prices, rather than composite measures that capture the multidimensional nature of food security. Moreover, while population growth is frequently included as an explanatory variable, it is often examined alongside numerous other factors without isolating its specific effect on a comprehensive food security index. This limits the ability to draw clear conclusions about the independent role of demographic dynamics in shaping food security outcomes across regions.

In the context of Gorontalo Province, these gaps are especially pronounced. Although the province is characterized by a strong agricultural base, with the agriculture, forestry, and fisheries sector contributing a significant share to regional GDP, food security outcomes remain uneven across districts. Data from the Food Security Index indicate persistent disparities among regencies and cities over the 2018–2024 period, suggesting that agricultural potential alone does not guarantee uniform food security performance. Population growth, albeit at a moderating rate, continues to increase food demand and place pressure on land, infrastructure, and social services, potentially influencing the province's overall food security trajectory.

Against this backdrop, the present study aims to analyze the effect of population growth on the Food Security Index in Gorontalo Province during the period 2018–2024. By focusing explicitly on population growth as the primary explanatory variable, this study seeks to clarify its role within a multidimensional food security framework. The use of the Food Security Index, which integrates indicators of availability, access, and utilization, represents a key contribution, as it allows for a more comprehensive assessment than single-indicator approaches. The novelty of this study lies in its subnational focus on Gorontalo Province and its emphasis on isolating the demographic effect within a composite food security measure. The scope of the study is limited to the provincial level and the specified time period, providing empirical evidence that is directly relevant for regional policy formulation and the design of population-sensitive food security strategies.

2. Methodology

This study employs a quantitative explanatory approach to analyze the effect of population growth on the Food Security Index (FSI) in Gorontalo Province during the period 2018–2024. The analysis focuses exclusively on the first research objective, namely examining population growth as the sole explanatory variable influencing food security. The unit of analysis consists of regencies and cities within Gorontalo Province, selected due to their agrarian characteristics and observed disparities in food security outcomes despite the dominant role of the agricultural sector in the regional economy.

The study utilizes secondary panel data derived from official sources. Population growth data are obtained from the Central Statistics Agency (Badan Pusat Statistik/BPS), which defines population growth as the annual percentage change in the total population (BPS, 2020). Food security data are sourced from the Food Security Index (Indeks Ketahanan Pangan/IKP) published by the National Food Agency, a composite indicator reflecting the dimensions of food availability, access, and utilization as mandated under Law No. 18 of 2012 on Food and Government Regulation No. 17 of 2015 on Food Security and Nutrition. The combination of cross-sectional (regency/city) and time-series (2018–2024) observations forms a balanced panel dataset.

To estimate the relationship between population growth and food security, the study applies linear panel regression analysis. The general model specification relates the Food Security Index to population growth, with estimation conducted using alternative panel data models, including pooled ordinary least squares, fixed effects, and random effects, to identify the most appropriate specification. Hypothesis testing is performed to assess the statistical significance and direction of the population growth coefficient. The methodological scope is limited to capturing the direct effect of population growth on food security, allowing for a focused and empirically grounded assessment of demographic pressure on food security dynamics in Gorontalo Province.

3. Results and Discussion

3.1. Overview of Population Growth and Food Security Dynamics in Gorontalo Province

The empirical analysis of this study focuses on examining the effect of population growth on the Food Security Index (FSI) in Gorontalo Province during the period 2018–2024. This period reflects recent demographic and food security dynamics and captures short- to medium-term trends that are relevant for regional policy formulation. Gorontalo Province experienced a continued increase in population throughout the study period, although the rate of growth showed signs of moderation in recent years. Despite this deceleration, the absolute increase in population has remained substantial enough to generate additional demand for food, public services, housing, and infrastructure.

At the same time, food security performance in Gorontalo Province, as measured by the Food Security Index, exhibited noticeable variation across regencies and cities as well as across time. While some areas, particularly urban centers, consistently recorded relatively high FSI scores, several regencies showed fluctuating or comparatively lower levels of food security. This pattern indicates that food security in Gorontalo cannot be explained solely by aggregate agricultural potential, which remains strong given the dominant contribution of the agricultural sector to regional Gross Regional Domestic Product. Instead, demographic pressure, including population growth, appears to play a meaningful role in shaping food security outcomes across the province.

The descriptive overview suggests that population growth and food security are not evolving independently. As population increases, pressure on food systems intensifies, especially in regions where agricultural land, productivity, and distribution infrastructure face structural constraints. These contextual observations provide an important backdrop for interpreting the econometric results of the panel data analysis.

3.2. Effect of Population Growth on the Food Security Index

The panel regression results indicate that population growth has a statistically significant effect on the Food Security Index in Gorontalo Province during the 2018–2024 period. The estimated coefficient for population growth is negative, suggesting that higher rates of population growth are associated with lower levels of food security, as reflected in declining FSI scores. This finding implies that demographic expansion, when not accompanied by proportional improvements in food availability, access, and utilization, tends to weaken overall food security conditions.

This result is consistent with classical demographic theory, particularly the Malthusian perspective, which argues that population growth tends to outpace the growth of food production, thereby creating structural pressure on food systems (Pieris, 2015). Although modern agricultural technologies and market mechanisms have mitigated some of the dire predictions associated with Malthusian theory, the core concern regarding imbalance between food demand and supply remains relevant, especially in regions with limited capacity for rapid productivity gains or land expansion.

In the context of Gorontalo Province, population growth increases aggregate food demand while simultaneously intensifying competition for land and natural resources. Agricultural land, particularly irrigated rice fields, faces growing pressure from residential development and infrastructure expansion. As a result, even modest population growth can translate into significant challenges for food availability at the local level. The negative relationship identified in this study underscores the vulnerability of food security systems to demographic change when structural constraints are present.

3.3. Population Growth and the Availability Dimension of Food Security

One of the primary channels through which population growth affects food security is food availability. As population increases, the demand for staple foods rises, requiring either higher domestic production or increased reliance on interregional trade and imports. In Gorontalo Province, agricultural production remains a central pillar of the regional economy, yet production growth has not always kept pace with population-driven demand increases.

The regression results suggest that population growth exerts downward pressure on the Food Security Index partly by constraining the availability dimension. This finding aligns with empirical evidence from other regions, which shows that population growth can dilute per capita food availability when agricultural output grows at a slower rate (Wehantouw et al., 2021). Although Gorontalo possesses significant agricultural potential, fluctuations in productivity, climate variability, and land conversion reduce the ability of the agricultural sector to fully offset rising demand.

Moreover, population growth contributes indirectly to land-use change, particularly through the conversion of agricultural land to residential and commercial uses. Such conversion reduces the effective area available for food production, further weakening the availability pillar of food security. This dynamic reinforces concerns raised by Neo-Malthusian scholars regarding the interaction between population pressure, resource constraints, and environmental degradation, even when population growth rates are moderate.

3.4. Implications for Food Access and Economic Entitlements

Beyond availability, population growth also influences food security through its effects on food access. According to Amartya Sen's Entitlement Theory, food insecurity often arises not from insufficient food supply but from failures in economic and social access to food (Sen, 1981). Population growth can exacerbate such failures by intensifying competition in labor markets, suppressing wages, and increasing the number of households that depend on limited income sources.

In Gorontalo Province, population growth has implications for employment and income distribution, particularly in rural areas where livelihoods are closely tied to agriculture. As the labor force expands faster than the availability of productive employment opportunities, household purchasing power may decline, reducing the ability of families to access adequate and nutritious food. This mechanism helps explain why food security outcomes may deteriorate even when aggregate food production remains relatively stable.

The negative association between population growth and the Food Security Index identified in this study is therefore consistent with Sen's argument that demographic pressure can weaken entitlements, especially among vulnerable groups. Households with limited access to land, capital, or stable employment are more likely to experience food insecurity as population growth intensifies competition for scarce resources. This finding highlights the importance of considering access-related dimensions of food security in demographic analyses.

3.5. Population Growth, Utilization, and Human Development Outcomes

The utilization dimension of food security, which encompasses nutritional status, health, and the effective use of food, is also indirectly affected by population growth. Rapid or sustained population increases can strain public services such as healthcare, sanitation, and education, all of which are critical for ensuring proper food utilization. When population growth outpaces improvements in service provision, nutritional outcomes may deteriorate even if food availability and access are maintained at minimal levels.

Although this study does not disaggregate the Food Security Index into its individual components, the negative overall effect of population growth suggests that utilization-related factors may also be adversely affected. Previous studies indicate that higher population density and rapid demographic change are often associated with increased prevalence of malnutrition and stunting, particularly among children, due to limited access to healthcare and clean water (Kristiawan, 2020).

In Gorontalo Province, disparities in access to health and nutrition services across regencies further amplify the impact of population growth on food utilization. Regions with weaker health infrastructure may struggle to maintain adequate nutritional outcomes as population increases, thereby contributing to lower Food Security Index scores. This reinforces the view that population growth affects food security through multiple, interconnected pathways rather than a single mechanism.

3.6. Comparison with Previous Empirical Studies

The findings of this study are broadly consistent with previous empirical research examining the relationship between population growth and food security. Studies conducted in other Indonesian provinces and developing regions generally report a negative association between population growth and food security indicators, particularly when demographic expansion is not matched by improvements in productivity and income (Sukamdi and Partiwi, 2010; Wehantouw et al., 2021). International evidence also supports this pattern, with analyses in countries such as Egypt and Nigeria demonstrating that population growth can undermine food security in the absence of adaptive policy measures (Hanafy, 2018; Nnamani and Ugwu, 2020).

However, some studies have identified conditions under which population growth may coincide with improved food security, particularly when demographic change is accompanied by economic growth, technological progress, and effective governance. Keynesian and endogenous growth perspectives suggest that population growth can stimulate demand and innovation, potentially supporting food system development in the long run. The results of the present

study indicate that such positive dynamics have not yet fully materialized in Gorontalo Province, at least within the 2018–2024 period.

The divergence between theoretical optimism and empirical outcomes underscores the importance of contextual factors. In regions where institutional capacity, infrastructure, and investment are limited, population growth is more likely to exert a negative influence on food security. This study contributes to the literature by providing subnational evidence that reinforces the relevance of demographic factors in shaping food security outcomes.

3.7. Policy-Relevant Interpretation of the Findings

From a policy perspective, the negative effect of population growth on the Food Security Index highlights the need for population-sensitive food security strategies in Gorontalo Province. Policies aimed solely at increasing agricultural production may be insufficient if they do not account for rising food demand driven by demographic change. Integrated approaches that combine food system development with population management, employment creation, and social protection are essential.

The findings also suggest that regional food security planning should incorporate demographic projections to anticipate future demand pressures. Investments in agricultural productivity, land protection, and distribution infrastructure must be scaled in line with population trends to prevent further erosion of food security. At the same time, policies that strengthen household entitlements, such as income support, employment programs, and access to education and health services, can mitigate the access-related effects of population growth.

It is important to interpret the results of this study within the defined analytical scope. The focus on population growth as the sole explanatory variable means that the estimated effect represents a partial relationship rather than a comprehensive explanation of food security dynamics. Other factors, such as poverty, economic growth, and environmental change, also play significant roles but are beyond the scope of this analysis.

Nevertheless, the consistency of the findings with established theory and empirical evidence strengthens confidence in the conclusion that population growth constitutes a meaningful determinant of food security in Gorontalo Province. By using a composite Food Security Index and panel data analysis, this study provides robust evidence that demographic pressure remains a critical challenge for regional food security, even in agriculturally endowed regions.

Overall, the results underscore the importance of addressing population dynamics as an integral component of food security policy. Without proactive and coordinated interventions, continued population growth may further constrain Gorontalo Province's ability to achieve equitable and sustainable food security outcomes in the future.

4. Conclusion

This study examines the effect of population growth on the Food Security Index (FSI) in Gorontalo Province during the period 2018–2024 and provides clear empirical evidence that demographic dynamics play a significant role in shaping regional food security outcomes. The results demonstrate that population growth has a statistically significant and negative effect on the Food Security Index, indicating that increases in population place measurable pressure on food security when not accompanied by proportional improvements in food system capacity. This finding highlights that food security challenges in Gorontalo cannot be attributed solely to production-related factors, despite the province's strong agricultural base.

The discussion shows that population growth affects food security through multiple, interconnected pathways, including increased demand for food, pressure on agricultural land, and weakened economic access for vulnerable households. These mechanisms align with classical demographic theory and entitlement-based perspectives, reinforcing the relevance of population growth as a structural determinant of food security. By employing a composite food security index and panel data analysis at the subnational level, this study contributes to the existing literature by providing context-specific evidence from an agrarian province in eastern Indonesia, an area that remains underrepresented in empirical food security research.

The findings carry important policy implications, suggesting that food security strategies should explicitly incorporate demographic considerations alongside agricultural and economic interventions. Future research could extend this analysis by integrating additional socioeconomic and environmental variables or by examining household-level impacts to further clarify the mechanisms through which population growth influences food security over time.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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