Feeding Nations: Domestic Food Production and Food Security in SAARC Countries through a Panel Ordered Probit Lens

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Introduction

South Asia is the second most poorest region in the world (SAARC, 2020). During the late 20th Century, the South Asian Alliance for Regional Cooperation (SAARC), discerned a boom in agriculture, enhanced by the Green Revolution, resulting in high-yielding crop varieties and high-input intensity (Tiwari et al., 2017). However, it was difficult for SAARC nations to cater to the growing demand caused by rapid population growth and urbanisation. Most of these countries faced significant economic changes over time, but their poverty and undernourishment levels are still concerning, and must be diligently addressed. The novel introduction of the three-tiered categorisation of the Food Production Index (FPI) helps to identify the probability of the SAARC nations being low, moderate or high food secure. This study employs a panel ordered probit analysis; a technique not previously applied to this type of econometric study.

It has been identified that land used for production, varying climate patterns and rising Carbon dioxide (CO2) emissions are key determinants of food security across SAARC nations (Behera et al., 2024). The SAARC region has experienced economic growth over the last few decades (Tiwari et al., 2017), while still retaining the highest rural population out of all other developing regions (FAO, 2001). Hence, it is vital to ensure the food security of these nations by focusing whether adequate food is produced to sustain its population. The study intends to contribute to the SDGs by exploring the impacts of greenhouse gases, expanding arable land and uncontrollable population growth, alongside persistently low food security levels which impacts the entire ecology.

Objectives

The objective of this study is to collectively and qualitatively assess the impact of population growth, GHG, urbanisation, agricultural land, PGDP and renewable energy on food security in SAARC countries.

Methodology

This study utilises data from "The World Bank Group" and "Our World in Data" for the period from 1993 to 2023, including 33 countries in the Asia region as depicted in table 1.

Table 1: Variable description

Variable	Measurement Unit
Food Security	Food Production Index (2014-2016 =100)
Urbanisation	Share of the population living in urban areas
Renewable Energy Consumption	Percentage of total final energy consumption
Greenhouse Gas Emissions	Tonnes of CO_2 equivalent
Population Growth	Annual percentage change in population size
Gross Domestic Product per Capita	GDP per capita (constant 2015 USD)
Agricultural Land	Land under cereal production (hectares)

Source: Authors' compilation

The purpose of this study is to estimate the probability of a country being categorised as low, moderate, or high food secure. To figure out the odds that a country might fall into one of the categories, a Panel Ordered Probit Model was used. While authors have taken independence in categorising FPI into three categories as adapted by previous studies (Macalou et al., 2023), equation 1 depicts the thresholds set for each category.

$$FP_{it} = \begin{cases} 1 \text{ if } FP_{it}^{*} \leq 48 \\ 2 \text{ if } 48 < FP_{it}^{*} \leq 112 \\ 3 \text{ if } FP_{it}^{*} > 112 \end{cases} \quad (1)$$

Equation 2 sets out the panel ordered probit model for Asian countries.

$$FP_{it}(1,2,3) = \chi_i(\beta_1 PG + \beta_2 GHG + \beta_3 UB + \beta_4 AGRI + \beta_5 PGDP + \beta_6 RE)_{it} + \varepsilon_{it} \quad (2)$$

Where in equation 2, UB represents urbanisation, GHG indicates greenhouse gas emissions, RE represents renewable energy, PG indicates population growth, AGRI represents agricultural land, and PGDP represents gross domestic product per capita. $FP_{it}(1,2,3)$ establishes the degree to which a country fits into one of the defined categories. Prior to panel ordered probit, the study employed Breusch Pagan Test and the Variance Inflation Factor test, where it was concluded that the data was homoscedastic and free of multicollinearity.

Results and Discussions

Table 2 depicts the panel ordered probit results generated using Asian countries' data. Results reveal that urbanisation, renewable energy consumption, population growth, and agriculture land have a significant relationship with FPI. All variables indicate signs as expected. Urbanisation indicates that with one percent rise in urban residents, the likelihood of a country being categorized as low food secure falls by 0.48%, and the likelihood of it being categorized as high food secure rises by 0.61%, assuming other variables remained constant. Similarly in the context of agricultural land, when arable land rises by a percent, the probability of a country being low food secure falls by 0.42%, while it being categorised as high food secure rises by 0.53%.

In the context of renewable energy, land use competition and water stress would justify the negative correlation, with population growth indicating the same correlation. When GHG rises by a percent the odds of a country being categorised as high food secure falls by 0.94% due to environmental degradation and climate deterioration, parallelly while the odds of the country being categorised as low food secure rises by 0.68%. Similarly, when population growth rises by 1%, the chance of a country being high food secure falls by 0.85% and it being categorised as low food secure rises by 0.68%, assuming other variables remain constant.

Table 2: Panel Ordered Probit Results

Variables	Estimate	SE	Marginal Effects		
			Low food secure	Moderate food secure	High food secure
UB	0.0462***	0.0136	-0.0048***	-0.0013	0.0061***
GHG	-0.1485	0.1032	0.0155	0.0040	-0.0195
RE	-0.0717***	0.0089	0.0068***	0.0019	-0.0094***
PG	-0.0649**	0.0310	0.0068*	0.0018	-0.0085**
AGRI	0.0405*	0.0212	-0.0042*	-0.0011	0.0053*
PGDP	0.0195	0.1567	-0.0020	-0.0005	0.0026
Ancillary Parameters					
$\hat{\gamma}_1$	-1.0751	0.9259			
$\hat{\gamma}_2$	2.5626	0.9540			
χ^2	101.45				
LPL	-540.23				
Obs.	1023				

Note: The coefficients presented above represent marginal effects with the significance levels: * significant at 10%, ** significant at 5%, and *** significant at 1%. χ^2 represents waldchi^2, Obs. represent number of observations, LPL represents log pseudolikelihood.

Source: Authors' compilation using Stata software.

Extending the study into the SAARC nations, table 3 depicts the averaged probabilities for the period of 1993 to 2023.

Table 3: Averaged probabilities of SAARC countries

Country	Low food secure	Moderate food secure	High food secure
Bangladesh	0.547	0.349	0.104
Bhutan	0.893	0.100	0.007
India	0.141	0.424	0.436
Maldives	0.191	0.459	0.350
Nepal	0.925	0.071	0.004
Pakistan	0.551	0.367	0.083
Sri Lanka	0.773	0.203	0.024

Source: Authors' compilation using Stata software.

Focusing on the likelihood of a country being categorised as low food secure, it is found that, Nepal indicates the highest probability of 93%, followed by Bhutan at 89%, Sri Lanka at 77%, Pakistan at 55% and Bangladesh at 54% approximately. While the world pays high attention towards strengthening the food security, it is important that the above-mentioned countries focus on restructuring their policies to meet the current changes in economies, society and environment that would impact their food production levels.

It is important to remember that the image conveyed by statistics could be brought up to question as most households, much significantly in the Southeast Asia rely on subsistence farming to meet their daily requirements of food. Rich soil and structured irrigation systems built over years makes it easier for them to grow their own produce, though they are still challenged by extreme climate events.

Conclusion and Policy Recommendations

This research has found that population growth, renewable energy, and GHG emissions negatively contribute to the likelihood of being categorised as food secure, while urbanisation and agricultural land indicates a favourable influence on the odds of being food secure. PGDP and GHG show no significant relationship to food production.

Although being limited in arable land, Maldives remains moderately food secure, likely due to stable population trends and sustainable practices, while India's rapid urbanisation, increasing solar power adoption and rising PGDP, continues to strengthen their food security outcomes.

In contrast, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka face higher risks of food insecurity, thereby requiring urgent, targeted actions. Nepal can focus on supporting farmer-producer organisations, while expanding rural road connectivity for better food market access in the long run. Meanwhile, Pakistan should provide food voucher schemes for vulnerable households, while investing in rainwater harvesting in the long run. Bangladesh can focus on offering subsidised crop insurance to farmers, with a long-term focus on investing in climate-resilient infrastructure. Similarly, Bhutan could initiate school feeding programmes that link to local farmers, while investing in

long-term term renewable-powered cold storage for longer preservation of consumables. Meanwhile, Sri Lanka should diversify food sources through crop variety development in the short run, while pursuing long-term investments in disaster-resilient food storage, and private sector aggrotech partnerships. Regionally, all SAARC nations should expand food aid programmes in the immediate future, with a long-term focus on strengthening regional trade agreements to ensure stable food supply chains and building cross-border infrastructure for food storage and transport for securing food systems in South Asia.

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