

A Thesis
on
Evaluating the Relationships between Population, Production and
Arable Land of Four Asian Countries

This report is submitted to the Department of Accounting, Faculty of Business Studies, Hajee Mohammad Danesh Science and Technology University, Dinajpur for the fulfillment of the degree of Master of Business Administration (MBA) program.



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Certificate of Supervisor

I hereby declare that the report '*Evaluating the Relationships between Population, Production and Arable Land of four Asian Countries*' is work by Md. Juwel Rana, Student ID: 1603169, MBA in Accounting and Information Systems (MBA-AIS), Faculty of Business Studies. Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, completed his research program under my supervision and submitted for the fulfillment of the requirement of the degree of Master of Business Administration (MBA), in Accounting and information Systems (MBA-AIS), at HSTU, Dinajpur.

I wish him every success in life.

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The report titled "Evaluating the Relationships between Population, Production and Arable Land of four Asian Countries" has been submitted with the department, in partial fulfillment of the degree of MBA at the Department of Accounting, Hajee Mohammad Danesh Science and Technology University, Dinajpur by Md. Juwel Rana, Student ID no. 1603169. I have gone through the report and have tried to come out with the best within the capacity of the student. The report has been accepted and may be presented before the defense committee for evaluation and assessment.

I wish him every success in life.

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Student's declaration

I hereby declare that the study entitled '*Evaluating the Relationships between Population, Production and Arable Land of four Asian Countries*' embodies the result of my own works and efforts, prepared under the supervision of Dr. Shaikh Mostak Ahammad, Professor, Department of Accounting, Hajee Mohammad Dansesh Science and Technology University, Dinajpur.

I further confirm that the work and material included in this thesis report are original and have not been submitted to any form or any other university or institution for any credit or any other reason.

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Abstract

This study aims to evaluate the relationships between population, production, and arable lands in four Asian countries (Bangladesh, India, Malaysia, and Nepal) using a panel data framework for the period 1990–2020. The main objective of this research is to evaluate the relationships between population growth, agricultural production, and the use of arable land. This analysis presents how population growth and increasing food demand impact the utilization of arable land as well as the production of crops. It's also examining the relationships between population growth and the productivity of agricultural land and the impact of population growth on the quality of arable land. The data for this research collects from the Food and Agriculture Organization (FAO) database. It also uses statistical analysis to interpret the data, using EViews software. It undertakes a panel unit root test and panel cointegration analysis to investigate the long-run relationships between variables. In addition, panel impulse response functions (IRFs) are also used to investigate the direction of causality over the short- and long-term as well as the impact of responses between population, production, and arable land. The results of the research help identify the factors that affect agricultural productivity and sustainability. The research aims to provide insight into how population growth impacts agricultural production and the utilization of arable land.

Keywords: Population, Production, Arable land, Unit root, Cointegration.

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List of Abbreviation

Abbreviation	Elaboration
FAO	Agriculture and Food Organization
IRFs	Impulse Response Function
OLS	Ordinary Least Squares
FMOLS	Fully Modified Ordinary Least Squares
DOLS	Dynamic Ordinary Least Squares
Fisher ADF	Augmented Dickey fuller
VAR	Vector auto regression

CHAPTER 1

Introduction

1.1. Introduction

The relationships between population, production, and arable land are key issues for many countries, particularly in the developing world where food security and economic development are major concerns. In Asia, a region with a rapidly growing population and increasing demand for food and other agricultural products, understanding the dynamics of this relationship is crucial for policymakers and researchers alike. The four countries included in this study—Bangladesh, India, Malaysia, and Nepal—are all located in Asia and share many commonalities, including a strong dependence on agriculture for both livelihoods and economic growth. It also exhibits significant differences in terms of population size, economic development, and agricultural practices. This study aims to investigate the relationship between population, production, and arable land in these four countries over the period from 1990 to 2020, using data collected from the Food and Agriculture Organization (FAO). Specifically, it explores how changes in population size and agricultural practices have affected agricultural production and the availability of arable land in each country. Population growth is a key driver of food demand, and the increasing population in these countries has put significant pressure on agricultural production. At the same time, changes in agricultural practices, including the adoption of new technologies and the expansion of agribusiness, have led to increased productivity and output. The availability of arable land is also a critical factor in agricultural production, and changes in land use patterns can have significant impacts on food security and economic growth.

This research will be significant in providing insights into how the increase in population affects food security and sustainability and how these impacts can be managed. It will also guide how to balance the increasing demand for food with the need to protect the environment. This research will be beneficial to policymakers, researchers, and stockholders interested in the linkages among population growth, food production, and land use changes.

1.2. Objective

The objective of this research topic is to evaluating the relationships between population, production, and arable land in four Asian countries (Bangladesh, India, Malaysia, and Nepal). The research aims to evaluate the relationships among these three variables over the period (1990–2020) and explore the inter-relationships among them.

CHAPTER 2

Literature Review

A literature review is not only a crucial endeavor for any academic research but also the foundation and inspiration for substantial, useful research. There are lots of literature reviews on this topic.

Islam et al. (2019) showed that population density harms agricultural production, while the availability of arable land has a positive impact. They also found that the impact of population density on agricultural production is more pronounced in areas with less arable land. Radam et al. (2012) evaluated that the availability of arable land has a significant impact on the level of agricultural productivity. They also found that the relationship between population and arable land is complex and that policies aimed at promoting the sustainable use of arable land need to consider both population and production factors. Shakya and Tiwari (2019) found that population growth has a negative impact on agricultural productivity and land use. They also found that land use and population growth are interdependent and that policies aimed at controlling population growth can help to ensure the sustainable use of arable land. Cassman et al. (2013) discussed the challenges of meeting increasing global food demand, including the need to increase yields to maximize production from existing arable land. It may be useful in understanding the relationship between population growth, food demand, and the need for increased agricultural productivity.

Hertel et al. (2010) examined the potential implications of climate change on crop yields and the resulting impact on global poverty levels. It may be useful in understanding the complex relationships among population growth, agricultural production, and climate change impacts on arable land. Jayasinghe-Mudalige and Seneviratne (2019) provided a spatial analysis of land use change in Sri Lanka and its relationship with population growth. Their findings suggest that population growth has had a significant impact on land use change, particularly in urban areas. Cossar and Karam (2017) examined the spatial relationship between population growth and land use change in India. They find that population growth has led to increased agricultural land use but also to the conversion of forest land and other non-agricultural areas. Deolalikar and Naidu (2017) focused on the relationship between population growth and food security in India. They find that population growth has harmed food security, but increasing agricultural production could help mitigate this effect

Bashir and Schilizzi (2019) examined the impact of population growth on food production and arable land in Pakistan. They find that population growth has led to a decrease in arable land per capita, which could have implications for food security in the future. Fawole and Adeola (2017) investigated the relationship between population growth and agricultural production in Nigeria. The authors note that Nigeria is the most populous country in Africa, and its population is expected to grow to 300 million by 2050. This growth in population presents a significant challenge to the country's food security, as agricultural production has not kept pace with population growth. Bhattacharya (2017) showed the relationship between population growth, agricultural production, and land use in India. The study was used to analyze the effects of population growth on agricultural production and land use in India. The study employs regression analysis to identify the factors that influence agricultural production and land use.

Kao (1999) established the unit root test; it was an important contribution to the econometrics literature and has been cited in many subsequent studies on panel data cointegration and unit root testing. Im, Pesaran, and Shin (2003) introduced the IPS test. In this paper, the authors derive the asymptotic distribution of the IPS test statistic and demonstrate its superior performance compared to other panel unit root tests, especially under cross-sectional dependence and heterogeneity. Pedroni (2004) provided an overview of the asymptotic and finite sample properties of pooled time series tests for panel cointegration and included an application to the PPP hypothesis (purchasing power parity). Levin et al. (2002) examined a new test for unit roots in panel data that takes into account cross-sectional dependence and compares the properties of this test to other existing tests. Harris and Tzavalis (1999) showed that unit roots exist in dynamic panels where the time dimension is fixed. The paper proposes a new test for unit roots in panel data that takes into account both cross-sectional dependence and heterogeneity and compares the properties of this test to those of other existing tests. Pretty, J. (2008) showed an overview of the concept of agricultural sustainability and discussed the principles and evidence supporting sustainable agriculture practices. The author argues that sustainable agriculture practices can help address environmental, economic, and social challenges such as climate change, poverty, and food insecurity. The paper emphasizes the need for a transition towards more sustainable agricultural systems and provides examples of successful sustainable agriculture initiatives.

Tilman et al. (2002) discussed the trade-offs between intensive agricultural production practices and sustainability and examined the potential benefits and drawbacks of different approaches to sustainable agriculture. The authors argue that sustainable agriculture can improve environmental and economic outcomes but that there are often trade-offs between sustainability and productivity. The paper highlights the need for integrated approaches to sustainable agriculture that consider both environmental and economic factors. Pingali, P. L. (2007) provided a critical review of the literature on the relationship between agricultural growth and economic development, with a focus on the role of globalization. The author argues that globalization has created new opportunities for agricultural growth but that there are also risks and challenges associated with it. The paper highlights the need for policies that support inclusive and sustainable agricultural growth and emphasizes the importance of taking into account the social and environmental dimensions of agricultural development.

Shahbaz et al. (2016) investigated the relationship between population, agricultural land, and food production in five South Asian countries, including Bangladesh, India, Pakistan, Sri Lanka, and Nepal. The authors use panel data analysis techniques to examine the long-run and short-run dynamics among these variables. Kibria et al. (2019) examined the relationship between population, agricultural land, and food production in four South Asian countries, including Bangladesh, India, Pakistan, and Sri Lanka. The authors use a vector autoregressive (VAR) model to estimate the dynamic interactions among these variables. Islam et al. (2021) investigated the relationship between population growth, agricultural land use, and food production in six South Asian countries, including Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. The authors use a panel data analysis approach to estimate the long-run and short-run dynamics among these variables. Rezitis, A. N., and Ahammad, S. M. (2016) examined the dynamic relationship between energy consumption and economic growth in nine South and Southeast Asian countries (i.e. Bangladesh, Brunei Darussalam, India, Indonesia, Malaysia, Pakistan, the Philippines, Sri Lanka and Thailand) in a panel data framework. The time period for the study is 1990–2012, and the World Bank Development Indicators data set is used. This study undertakes panel cointegration analysis to investigate the relationship between energy consumption and economic growth.

In light of the literature reviewed above, that there is much work done on this topic but not related to four Asian Countries (Bangladesh, India, Malaysia, and Nepal). The current research uses a panel data framework to evaluate the relationships between population, production, and the use of arable land in four Asian countries.

CHAPTER 3

Methodology of the study

3.1. Research Methodology

The following methodology is suggested to make it easier to conduct a practical analysis of how population, production, and arable land are related in Asian countries. The first step is to collect data on population, production, and arable land from reliable sources such as the Food and Agriculture Organization (FAO). The collected data is also analyzed using panel data econometric techniques. Panel data refers to data on the same set of variables collected over time and across different units, such as countries in this case. Panel data allows for more efficient estimation and better control for unobserved heterogeneity compared to cross-sectional or time-series data. The panel unit root test will be conducted to check the stationarity of the variables. The commonly used panel unit root tests are the Levin-Lin-Chu (2002) test, the Im-Pesaran-Shin (2003) test, and the Fisher-type test. The next step is to check for cointegration among the variables. Cointegration refers to a long-term relationship among non-stationary variables. The commonly used panel cointegration tests are Pedroni, Kao, and Fisher's Augmented Dickey-Fuller (ADF). The next step is to estimate the model using appropriate econometric techniques such as ordinary least squares (OLS), fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS), and panel multivariate impulse response functions (IRFs). It should be noted that the estimations are performed using Eviews 10 econometric software and methodologies based on Cruz's work (2018).

3.2. Panel unit root analysis

The unit root test helps to determine whether a time series is stationary or non-stationary. If the series is non-stationary, it means that it has a unit root, which indicates that the series is trending and does not have a constant mean over time. On the other hand, if the series is stationary, it means that it does not have a unit root and is therefore constant over time. In panel unit root analysis, there are several tests available for investigating the unit root properties of the individual series in a panel data set. Some of the commonly used tests include the Levin-Lin-Chu (2002) test, the Im-Pesaran-Shin (2003) test, and the Fisher-type test. The Levin-Lin-Chu test is based on a non-parametric approach and has been found to have good power in finite samples. The Im-Pesaran-Shin test, on the other hand, is based on a

parametric approach and is more powerful than the Levin-Lin-Chu test in the presence of cross-sectional dependence. The Fisher-type test is based on a combination of the Liven-Lin-Chu and Im-Pesaran-Shin tests and has been found to have good power in the presence of both serial correlation and cross-sectional dependence.

According to Eviews 10 software it is assumed that. The hypothesis of unit root is as follows:

$$\begin{array}{ll} H_0: & \rho_i = \rho = 0 \\ & \text{and alternative hypothesis is} \\ & \text{for all } i \\ H_1: & \rho_i = \rho < 0 \end{array}$$

Null hypothesis: null hypothesis is that there has a unit root in the time series, data is non stationary.

Alternative hypothesis: alternative hypothesis is that there has no unit root in the time series, data is stationary.

Note: If the value of probability less than 5% then it rejects null hypothesis and accept alternative hypothesis.

3.3. Panel cointegration analysis

Panel cointegration is a statistical method used to test the long-run equilibrium relationship among two or more non-stationary time series in panel data. In this method, the non-stationary time series are first tested for unit roots and then used to test for cointegration using appropriate statistical tests. Pedroni (2004) suggested a panel cointegration test to test the presence of a long-run equilibrium relationship among the variables under consideration (population, production, and arable land). Pedroni (2004) created two sets of cointegration tests, each with seven data points. The v-statistic, panel R-statistic, panel pp-statistic, and panel ADF-statistic are four of the seven statistics in the first group; they are based on pooling along the within-dimension and are known as panel cointegration statistics. The final three statistics in the second set are based on pooling along the among-dimension and are known as group mean panel cointegration statistics: the group p-statistic, the group pp-statistic, and the group ADF-statistic. According to Eviews 10 software it is assumed that. The hypothesis of unit root is as follows.

$$H_0: \rho_i = \rho = 0$$

and alternative hypothesis is
for all i

$$H_1: \rho_i = \rho < 0$$

Null hypothesis: No cointegration.

Alternative hypothesis: cointegration exists.

Note: If the value of probability is less than 5%, then it rejects the null hypothesis.

According to Pedroni's (2004) cointegration test, regression analysis is a statistical technique used to investigate the relationships between one or more independent variables and a dependent variable. The model is specified such that the dependent variable is represented as a linear combination of the independent variables. This allows for the estimation of the impact of the independent variables on the dependent variable, providing insights into the nature and strength of the relationship among the variables $x_1, 2, \dots, t$,

Pedroni proposed several tests for cointegration that allow for heterogeneous intercepts and trends across cross-sections. Consider the following regression:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1,i} x_{1,i,t} + \beta_{2,i} x_{2,i,t} + \dots + \beta_{M,i} x_{M,i,t} + \varepsilon_{i,t} \dots \dots \dots (1)$$

Here,

y_{it} is the dependent variable for individual i at time t . α_i is the individual-specific intercept, which captures the fixed effect of individual i on the dependent variable y . δ_i is the individual-specific slope coefficient, which captures the fixed effect of time on the dependent variable y for individual i . $x_{1,i,t}$ to $x_{M,i,t}$ are M independent variables that vary over individuals and time, with $\beta_{1,i}$ to $\beta_{M,i}$ being the corresponding slope coefficients that measure the effect of each independent variable on the dependent variable for individual i . $\varepsilon_{i,t}$ is the error term that captures the unobserved factors affecting the dependent variable for individual i at time t .

The Kao (1999) test follows the same basic approach as the Pedroni tests but specifies cross-section-specific intercepts and homogeneous coefficients on the first-stage regresses. This is a regression model with panel data, which is used to estimate the relationship between a dependent variable (y) and two independent variables: a time-varying variable (x) and an individual-specific random error term (ε). The equation can be describes as:

$$y_{it} = \alpha_i + \beta x_{it} + C_{it} \dots \dots \dots (2)$$

$$y_{it} = x_{it-1} + U_{i,t} \dots \dots \dots (2.1)$$

$$x_{it} = x_{it-1} + \varepsilon_{i,t} \dots \dots \dots (2.2)$$

Here,

y_{it} is the dependent variable, α_i is a coefficients or parameters, C_{it} is an exogenous independent variable, x_{it} is an endogenous independent variable, $U_{i,t}$ is the error term or the residual which represents the difference between the predicted value and the actual value of y_{it} at time t, $\varepsilon_{i,t}$ is the error term or the residual, which represents the difference between the predicted value and the actual value of x_{it-1} at time t-1

Fisher (1932) derives a combined test that uses the results of individual independent tests. Fisher's result proposes an alternative approach to testing for cointegration in panel data by combining tests from individual cross-sections to obtain a test statistic for the full panel. It is the p-value from an individual cointegration test for the cross-section, then under the null hypothesis for the panel.

It is the p-value from an individual cointegration test for the cross-section, then under the null hypothesis for the panel,

Equation:

$$-2 \sum_{i=1}^N \log(\pi_i) \rightarrow \chi^2_{2N} \dots \dots \dots (3)$$

This reports the χ^2 value based on p-values for Johansen's cointegration trace test and maximum eigenvalue test.

When all variables are cointegrated, the next step is to calculate the long-run estimates. In the presence of cointegration, ordinary least squares (OLS) estimates do not give efficient results. Fully modified ordinary least squares (FMOLS) presented by Pedroni (2001) were applied to estimate long-run coefficients. The panel Fully Modified Ordinary Least Squares (FMOLS) estimator for the coefficient.

3.4. Data

Annual measurements from 1990 to 2020 were employed as the research's data source. The information came from the Food and Agriculture Organization (FAO). The information was acquired in October 2022 for Bangladesh, India, Malaysia, and Nepal, four countries in Asia. The natural logarithms of the population (InPOPU), production (InPROD), and arable land are included in the multivariate panel data technique (InARALAND). The table gives a thorough explanation of the facts. The use of natural logarithms helps to transform the data into a more meaningful and comparable scale, allowing for a better analysis of the variables relationships.

Table 1. Data description: Population, production, and arable land with measurement units.

Variables	Measurement units	Definition
Population	Billion	Population refers to the total number of individuals of a particular species living in a specific geographical area or habitat at a given time.
Production	Unit	Production is the process of creating goods or services that are useful to or desired by consumers. It involves using resources such as labor, capital, and technology to transform raw materials or inputs into finished products or services. Production can occur in various sectors, including manufacturing, agriculture, mining, construction, and services. The ultimate goal of production is to meet the demands of consumers and generate profits for the producers.
Arable land	Hectare	Arable land refers to land that is suitable for growing crops or plants. This type of land typically has a combination of fertile soil, an adequate water supply, and appropriate climate conditions that support the growth of crops. Arable land can be used for a variety of purposes, including food production, fiber production, and biofuel production.

Note: The definitions of variables are provided by Food and Agriculture Organization.

CHAPTER 4

Results and Discussion

4.1. Panel unit root test

The results of the panel unit root test are shown in Tables 1 and 2. The majority of panel unit root results have the propensity to fail to disprove the null hypothesis that a panel unit root does not exist for the levels of the variables. On the other hand, the majority of panel unit root results show that the alternative of stationary first differences of the variables is preferred over the null of a panel unit root of the first differences of the variables. As a result, it can be inferred from the panel unit root analysis that the variables are integrated, which raises the possibility of a long-run cointegrating relationship between variables like ln population, ln production, and ln arable land. As a result, the empirical analysis's next step is to look into whether the variables being considered are cointegrated.

Table 2: Results of Panel Unit Root LLC Tests and Fisher ADF tests:

LLC Test				ADF Test		
Variables in levels	None	Individual	Individual and trend	None	Individual	Individual and trend
Ln population	20.1930 (1.00)	-2.90119 (0.00)	-36.1791 (0.00)	4.58957 (0.80)	75.4945 (0.00)	276.978 (0.00)
Ln production	9.09452 (1.00)	-0.26493 (0.39)	0.70288 (0.76)	0.00122 (1.00)	2.38138 (0.97)	7.43851 (0.49)
Ln arable land	-4.55615 (0.00)	-1.17660 (0.18)	-0.39974 (0.34)	27.1847 (0.00)	14.4400 (0.07)	10.8073 (0.21)
Variables in 1 st difference						
Ln population	-10.2799 (0.00)	-216.194 (0.00)	-2610.09 (0.00)	297.771 (0.00)	38.1624 (0.00)	281.554 (0.00)
Ln production	-3.98065 (0.00)	-5.19955 (0.00)	-4.16931 (0.00)	25.1782 (0.00)	48.7523 (0.00)	37.2531 (0.00)
Ln arable land	-6.84666 (0.00)	-4.40353 (0.00)	-2.81980 (0.00)	62.4954 (0.00)	53.3502 (0.00)	40.0809 (0.00)

Note: Numbers in parentheses are P- Values.

Table 3: Results of panel unit root Fisher PP tests and IPS tests.

Fisher PP Test				IPS Test	
Variables in levels	None	Individual	Individual and trend	Individual	Individual and trend
Ln population	4.66206 (0.79)	76.7665 (0.00)	551.004 (0.00)	-13.1291 (0.00)	-76.1977 (0.00)
Ln production	0.00200 (1.00)	1.67245 (0.99)	15.5494 (0.05)	2.35944 (0.99)	0.64341 (0.74)
Ln arable land	49.4442 (0.00)	011.6463 (0.17)	8.41893 (0.40)	-0.69623 (0.24)	-0.96128 (0.17)
Variables in 1 st difference					
Ln population	337.348 (0.00)	73.6827 (0.00)	312.808 (0.00)	-197.876 (0.00)	-1809.87 (0.00)
Ln production	81.2066 (0.00)	108.942 (0.00)	121.499 (0.00)	-6.02406 (0.00)	-4.99276 (0.00)
Ln arable land	67.9463 (0.00)	62.6573 (0.00)	55.9767 (0.00)	-6.25522 (0.00)	-4.83319 (0.00)

Note: Numbers in parentheses are P- Values.

4.2 Panel cointegration results

Regarding the order of integration of this time series, unit root tests indicate that the variables are integrated. This data is non-stationary in level and stationary in their first differences. Therefore, panel cointegration testing can be implemented.

The result from Pedroni's, Kao's, and Johansen Fisher's panel cointegration tests is evaluated for both equation 1 and equation 2. There is a long-term relationship among population, production, and arable land.

In both cases, with only the intercept and again when the intercept and trend are included, most of Pedroni's statistics reject the null hypothesis of no cointegration among variables, indicating the existence of a panel long-run panel cointegration relationship between the observed variables (Table 4). Since four test statistics (the panel v-statistic, panel ADF statistic, group PP statistic, and group ADF statistic) out of seven reject the null hypothesis that there is no cointegration between population, production, and arable land at the

conventional level of significance, the cointegration test results support the presence of a long-run cointegrating relation among the variables. This means that the variables move together over the long term.

Table 5 shows the results of the Kao residual panel cointegration test for the variables Ln population, Ln production, and Ln arable land. The test is used to determine whether there is a long-run relationship between these variables. This shows that there is strong evidence of cointegration among the variables, indicating that they move together in the long run.

Table 6 presents the results of the Johansen-Fisher panel cointegration test, which is a statistical test used to determine the presence of cointegration between variables in a panel data set. Cointegration refers to a long-term relationship among variables that persists over time, and it is a necessary condition for conducting further analysis, such as estimating long-run relationships among variables. In the first row of Table 6, the null hypothesis is that there are no cointegrating equations. Both tests provide strong evidence against the null hypothesis, indicating the presence of cointegration among the variables in the panel dataset. In the second row of Table 6, the null hypothesis is that there is at most one cointegrating equation. The p-values are relatively high, indicating that there is not enough evidence to reject the null hypothesis. In the third row of Table 6, the null hypothesis is that there are at most two cointegrating equations. These results provide no evidence against the null hypothesis, indicating that there may not be any cointegrating relationships among the variables. The results of the Johansen-Fisher panel cointegration test present the presence of cointegration among the variables in the panel dataset, as evidenced by the strong evidence against the null hypothesis in the first row. However, the tests in the second and third rows of the table provide mixed results and indicate that further investigation is required to determine the number of cointegrating equations and the nature of the long-run relationships between the variables.

Table 4. Pedroni panel counteraction test

Intercept					Intercept and Trend			
	Statistic	P-Value	weighted statistic	P-Value	Statistic	P- Value	weighted statistic	P- Value
Panel Vs Statistic	0.779530	0.22	2.060826	0.02	-0.843459	0.80	0.273251	0.40
Penal rho Vs Statistic	-0.566745	0.28	-1.938214	0.03	0.624729	0.73	-0.448541	0.33
Panel pp vs Statistic	-2.409155	0.00	-4.072253	0.00	-1.751601	0.04	-3.694044	0.00
Panel ADF Vs Statistic	-3.437707	0.00	-3.854168	0.00	-2.919351	0.00	-3.853545	0.00
Group rho Vs Statistic	-2.457564	0.00			-0.789477	0.21		
Group PP Vs Statistic	-5.611131	0.00			-5.453591	0.00		
Group ADF Vs Statistic	-3.507924	0.00			-4.637917	0.00		

Table 5: Kao residual panel cointegration test

Variables	ADF	
	T-Statistic	P-value
Ln population ,Ln production ,Ln arable land	-8.327007	0.00

Table 6: Johansen Fisher panel cointegration test (Fisher)

Hypothesized no. of CE(s)	Fisher Stat* (form trace test)	P-value	Fisher Stat* (form maxeigen test)	P-value
None	57.13	0.00	52.12	0.00
At most 1**	12.88	0.12	13.35	0.10
At most 2**	5.909	0.64	5.909	0.66

4.3. Long –run equilibrium relationships

Tables 7, 8, and 9 present the findings of the long-run relationship between population, production, and arable land. Tables 7, 8, and 9 present the ordinary least squares (OLX), Fully Modified ordinary least squares (FMOLS), and Dynamic ordinary least squares (DOLS) estimators yield fairly comparable results for the complete panel in terms of the size and statistical significance of the parameter estimates.

Table 7 presents that both Ln population and Ln arable land have positive coefficients, indicating that they have a positive relationship with the dependent variable. The coefficient of Ln arable land is statistically significant, as evidenced by its t-statistic value of 20.06 and a p-value of 0.00, which is less than the significant level. The coefficient of Ln Population is not statistically significant, as evidenced by its t-statistic value of 0.95 and a p-value of 0.34, which is greater than the significant level of 0.05. This means that there is no significant relationship between population and food production. The model presents a high R-squared value of 0.77, indicating that it explains a significant proportion of the variance in the dependent variable. R-squared of 0.77 shows that the model is a good fit for the data.

Table 8 presents that there is a positive relationship between the $\ln$ population and food production, as the coefficient for an $\ln$ population is 0.42 and has a t-statistic of 0.33, indicating that the relationship is statistically significant. But the relationship between $\ln$ arable land and food production is not statistically significant, as the coefficient for $\ln$ arable land is 2.67 with a t-statistic of 1.58, and the p-value is not significant at the 5% level. Furthermore, the R-squared value of 0.88 indicates that the model explains 87.9% of the variation in food production, and the adjusted R-squared value of 0.88 indicates that the model is well-fit. The mean and standard deviation of the dependent variable, food production, are 11.55 and 11.55, respectively, and the standard error of the regression is 0.56. Overall, based on the Fully Modified Ordinary Least Squares (FMOLS) estimation and pooled model, it appears that population growth has a positive impact on food production, while the impact of arable land on food production is not statistically significant.

Table 9 presents that there is a positive relationship between the population and food production, as evidenced by the positive t-statistic of 0.11 and the significant p-value of 0.77. The coefficient estimate of 0.11 is relatively small, indicating that the effect of population growth on food production may be limited. On the other hand, the results show a negative relationship between arable land and food production, as evidenced by the negative t-statistic of -1.17 and the non-significant p-value of 0.66. This means that there are some other factors affecting food production, such as technological advancements and infrastructure development that are more important than arable land. The dynamic ordinary least squares (DOLS) estimation and pooled model provide valuable insights into the relationship between population, arable land, and food production. R-squared of 0.94 shows that the model is a good fit for the data. It is important to note that this analysis only considers these three factors; other factors such as climate change and economic policies may also have a significant impact on food production.

Table 7: Ordinary Least Squares Method (OLS)

Variable	coefficient	Std. Error	t- statistic	P-value
C	4.268007	1.136683	3.754793	(0.00)
Ln Population	0.239606	0.250909	0.954953	(0.34)
Ln Arable land	0.706144	0.035200	20.06090	(0.00)
R-squared	0.768851	Mean dependent VAR		11.56029
Adjusted R-squared	0.765031	S.D dependent VAR		1.585429
S.E. of regression	0.768515	Akaike info criterion		2.335183
Sum squared residual	71.46447	Schwarz criterion		2.403416
log likelihood	-141.7813	Hannan –Quinn criterion		2.362901
F-statistic	210.2364	Durbin – Watson stat		0.334157
pro-(F-statistic)	0.000000			

Note: Numbers in parentheses are P- Values.

Table 8: Fully Modified Ordinary Least Squares Method (FMOLS).

Variable	coefficient	Std. Error	t- statistic	P-value
Ln Population	0.332687	0.421462	0.789364	(0.43)
Ln Arable land	1.581889	2.664741	0.593637	(0.55)
R-squared	0.879179	Mean dependent VAR		11.55277
Adjusted R-squared	0.873880	S.D dependent VAR		11.55277
S.E. of regression	0.563843	Sum squared residual		36.24276
Sum squared residual	0.528777			

Note: Numbers in parentheses are P- Values.

Table 9: Dynamic Ordinary Least squares method (DOLS).

Variable	coefficient	Std. Error	t- statistic	P-value
Ln Population	0.109456	0.368044	0.297399	(0.77)
Ln Arable land	-1.174164	2.632503	-0.446026	(0.66)
R-squared	0.945130	Mean dependent VAR		11.53043
Adjusted R-squared	0.925725	S.D dependent VAR		1.592824
S.E. of regression	0.434099	Sum squared residual		15.45223
Sum squared residual	0.134125			

Note: Numbers in parentheses are P- Values.

4.5 Panel multivariate impulse response function (IRFs)

The panel impulse response functions (IRFs) in Figure 1 show the response of the three variables, population (LPOPU), production (LPRO), and arable land (ARLAND), to a one-unit shock in each variable. The shocks are generated for the four Asian countries considered in the analysis (Bangladesh, India, Malaysia, and Nepal).

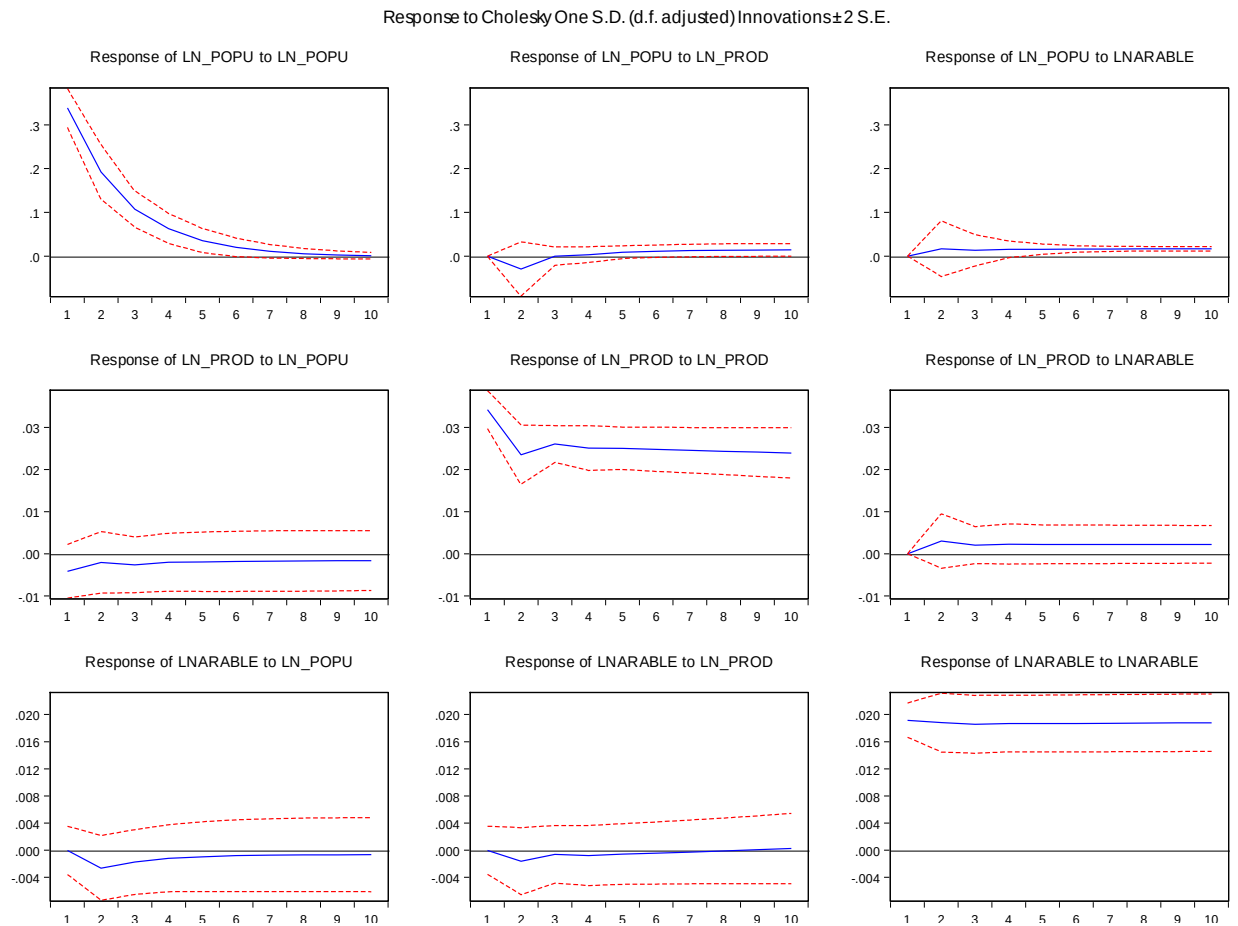


Figure 1. Panel multivariate impulse response function (IRFs) comparison of four Asian countries.

The first row of Figure 1 shows the response of each variable to a one-unit shock in the population. The graph shows that a one-unit shock in population has a negative effect on the population itself for a period of one to three years. This means that the population initially decreases in response to the shock before reaching an equilibrium level after three to four years. After four years, the population positively affects itself and remains stable. This row also shows that a one-unit shock in population has a positive effect on arable land, and this effect remains stable throughout the period. This row shows that an increase in population may lead to an increase in arable land, possibly due to greater demand for food and agricultural production.

The second row of figure 1 shows the response of each variable to a one-unit shock in production. It also shows that a one-unit shock in production has a negative effect on the population initially, and this effect remains stable for the entire period of 10 years. This row also shows that an increase in production may not necessarily lead to an increase in

population in the short term. This row shows that a one-unit shock in production has a positive effect on arable land, and this effect remains stable throughout the period. This means that an increase in production may lead to an increase in the amount of arable land being used for agricultural purposes.

The third row of Figure 1 shows the response of each variable to a one-unit shock in arable land. This row shows that a one-unit shock in arable land has a negative effect on both population and production. This row also shows that a decrease in the amount of arable land may lead to decreases in both population and production in the short term. This figure shows that the negative effect on production reaches an equilibrium level after 7–8.5 years before becoming positive and remaining stable. It again shows that, over the longer term, a decrease in arable land may lead to adjustments in production that eventually offset the initial negative effects.

CHAPTER 5

Findings and Suggestions

5.1. Findings

- A panel unit root test shows that the variables $\ln$ population, $\ln$ production, and $\ln$ arable land are integrated. This implies that they are non-stationary in levels but stationary in the first differences.
- Pedroni panel cointegration tests indicate that most of the statistics reject the null hypothesis of no cointegration.
- Kao residual panel cointegration test shows strong evidence of cointegration among the variables in the long run.
- The Johansen-Fisher panel cointegration test provides mixed results, with evidence against the null hypothesis of no cointegrating equations but no evidence against the null hypothesis of at most one or two cointegrating equations.
- The coefficient for the arable land is statistically significant and has a positive relationship with the dependent variable. But the coefficient for the $\ln$ population is not statistically significant.
- The coefficient for $\ln$ population is statistically significant and has a positive relationship with production. But the coefficient for arable land is not statistically significant.
- The responses of all the variables to shocks reach the equilibrium level within four to five years.
- A one-unit shock in population positively affects arable land but has a slightly negative effect on production.
- A one-unit shock in production positively affects arable land but negatively affects a population.
- A one-unit shock in arable land negatively affects both the variables production and population.

5.2. Suggestions

- It may be appropriate to estimate a panel cointegration model that includes all the variables and use it to make predictions behavior of the dependent variable.
- Since the Kao residual panel cointegration test shows strong evidence of cointegration among the variables in the long run, this suggests that the model can capture the long-run relationship between the variables.
- It may be useful to conduct further analysis to determine if there are multiple cointegrating equations or if some variables are not contributing significantly to the long-run relationship.
- It may be necessary to include additional variables in the analysis. This statement implies that the model may need to be expanded to include additional variables that could have an impact on the dependent variable.
- This may imply that other factors, such as technological change or access to capital, are more important in determining agricultural production. So it may be necessary to include additional variables in the analysis to capture these factors.
- It may be encouraging sustainable agricultural practices that can help increase agricultural production without causing significant environmental damage.
- It may be promoting population control measures in countries where population growth rates are particularly high, such as India and Nepal, to reduce pressure on arable land.
- It may be increasing investment in agricultural research and development to identify new and innovative ways to increase productivity while minimizing the use of arable land.
- It may be encouraging the adoption of new technologies and practices that can help farmers produce more with less land, such as precision farming, crop rotation, and integrated pest management.
- It may be implementing policies to protect and preserve arable land, including zoning regulations, land-use planning, and sustainable land management practices.

CHAPTER 6

Conclusions, policy implications and future work

6.1. Conclusions

Based on the analysis of the data using unit root, cointegration, and impulse response function tests, it can be concluded that there exists a significant relationship between population, production, and arable land in the four Asian countries (Bangladesh, India, Malaysia, and Nepal) from 1990 to 2020. The results indicate that population has a positive and significant impact on production, and arable land has a positive and significant impact on both population and production. The findings present that the increase in population in these countries has led to an increase in demand for agricultural products, which in turn has resulted in higher production. Moreover, the increase in arable land has also significantly contributed to the increase in population and production. These results have important policy implications for these countries. With the growth in production and meeting the increasing demand for food, it is essential to ensure that adequate measures are taken to increase arable land and improve agricultural productivity. This can be achieved through the implementation of policies aimed at providing incentives for investment in agriculture, promoting research and development, and improving infrastructure such as irrigation systems. In addition, the findings present that policies aimed at promoting family planning and reducing population growth could have a positive impact on production, as it will help to reduce the pressure on the limited arable land resources. Therefore, policymakers must consider population control policies as an integral part of their agricultural development strategies. It is recommended to investigate the impact of other factors such as climate change, technology, and trade on the relationship between population, production, and arable land in these countries.

6.2. Policy Implications

Based on the findings of this study, it can be concluded that there is a significant relationship between population, production, and arable land in the four Asian countries of Bangladesh, India, Malaysia, and Nepal. The results show that as the population increases, so does the demand for agricultural products, which leads to an increase in production and a greater need for arable land. Conversely, as arable land decreases, it can lead to a decrease in production and ultimately impact the population's ability to access food. Governments in these countries

may prioritize the protection of arable land and the promotion of sustainable agricultural practices to ensure that there is enough food to meet the growing demand of their populations. Additionally, policies may be implemented to encourage the efficient use of available land and resources to ensure optimal production and avoid the negative impacts of land degradation and deforestation. Moreover, the study also highlights the need for continued monitoring and analysis of population growth and agricultural production to ensure that policies are effective in addressing the challenges of food security and sustainability.

6.3. Future work

Based on this study, there are several potential avenues for future research on the relationship between population, production, and arable land in the Asian countries of Bangladesh, India, Malaysia, and Nepal. Further investigation can be done to explore the impact of climate change on the relationship between population, production, and arable land. With the changing global climate, it is becoming increasingly important to understand the potential impacts on agriculture and food security. Future studies could consider the effects of technological advancements on the relationships between population, production, and arable land. Advancements in agricultural technology could potentially lead to increased production, which could have positive impacts on food security and economic growth. It will be interesting to explore the potential impact of government policies on the relationship between population, production, and arable land. Policies related to land use, agricultural subsidies, and population control can potentially have significant impacts on the relationship among these variables. Finally, future research can focus on the impact of globalization on the relationship between population, production, and arable land. The increasing interconnectedness of the global economy can potentially have both positive and negative impacts on agriculture and food security in these countries.

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