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Deepak Kumar[1]
Kamaljit Singh[2]
Sunil Phougat[3]

IMPACT OF AGRICULTURE LAND AND POPULATION DENSITY ON ECONOMIC GROWTH: AN EMPIRICAL EVIDENCE FROM INDIA[4]

India is an agrarian economy and stands 2nd in the world population. India is in sixth place in the list of the most significant economies globally and 3rd in the purchasing power after the United States and China. However, India still has many growing concerns like a declining share of agriculture in the GDP, rapid increment in the population, unemployment, and others. The present study investigated the linkage between agricultural land, population density, and economic growth in India. The data from 1970 to 2019 was analysed using a vector error correction model (VECM) and Granger causality test. Further, the variance decomposition (VDC) and impulse response function (IRF) was employed for a detailed explanation of the variables' relationship and innovation responses of explanatory variables. The Granger causality test results suggested that agricultural land and the gross domestic product have a neutral relationship. The population density and gross domestic product support the feedback hypothesis. Additionally, population density affects agricultural land, whereas agricultural land does not affect population density. From a policy perspective, policymakers should frame strategies to decide the nation's comprehensive significance of population density. Too high populace density diminishes the natural endowment per capita. However, it facilitates infrastructure development, prompting an ideal populace density for economic development.

Keywords: Agricultural Land, Population Density, Granger Causality, Economic Growth
JEL: N55; O13; Q10; Q56; F43

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[1] *Researcher, Department of Economics, Chaudhary Ranbir Singh University, Jind (Haryana), India, e-mail: deepak.crsu@gmail.com.*
[2] *Researcher, University School of Management, Kurukshetra University, Kurukshetra (Haryana), India, e-mail: kamaljitsehjanusm17@kuk.ac.in.*
[3] *Associate Professor, Department of Economics, Chaudhary Ranbir Singh University, Jind (Haryana), India, e-mail: sunilphougat@crsu.ac.in.*
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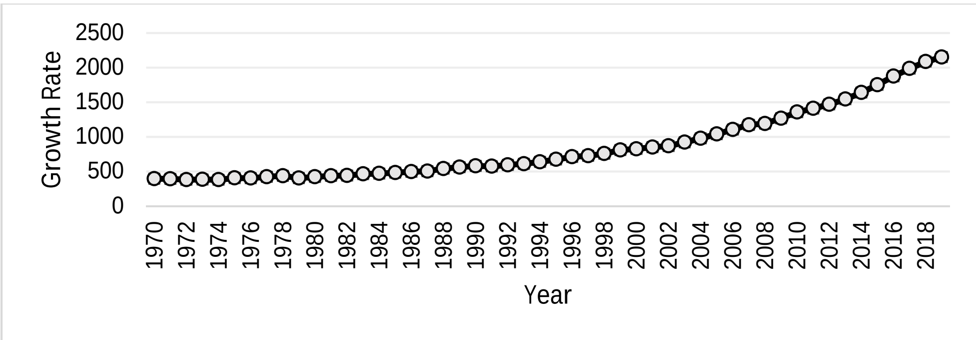
1. Introduction

Agriculture plays a strategic role in developing nations globally, especially in nations like India. Most of the population in developing nations living in rural areas, and the primary source of their livelihood in these countries is agriculture. According to the census of 2011, 69.9 percent population of India lives in rural areas and is involved in agriculture & its allied activities for their livelihood. India is in fifth place in the list of the most significant economies globally and 3rd in the purchasing power after the United States and China. However, India still has many growing concerns like a declining share of agriculture in the GDP, rapid increment in the population, unemployment, and others. Since the Indian economy has grown and diversified, the agriculture sector's contribution to Gross Domestic Product (GDP) has steadily declined from 1951 to 2011 (FAO).

At the time of the independence, agriculture was the primary sector contributing to India's GDP, followed by the industry & manufacturing, and service sectors. As the economy starts to grow, structural changes are taking place, and the share of agriculture is continuously declining. During the time of independence, agriculture contributes around 53 percent of India's GDP, and now this time service sector in India takes over agriculture and industry & manufacturing. The trend of economic growth over the years is shown in Figure 1.

Figure 1

Trend of economic growth

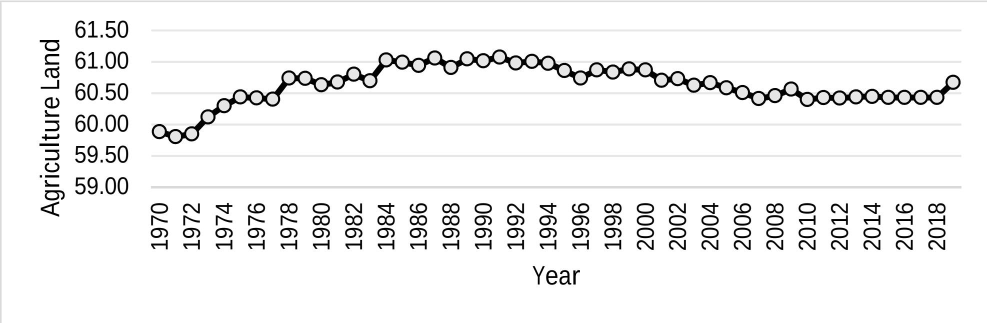


Source: www.data.world.co.in.

In 2020-2021, first time in the last 17 years agriculture sector made a record by contributing to India's GDP by approximately 20 percent (pib.gov.in). The covid-19 pandemic has destroyed most of the national economies around the globe. The Indian economy also showed a negative growth rate during the covid-19 period in 2020-2021, but agriculture is the only sector that had a positive growth rate in the Indian economy (Cariappa, 2021). Agriculture land is defined as "land currently used to produce agricultural commodities including forest products or land that have the potential for such production (Brewer, Boxley, 1981). The trend of agriculture land over the years is shown in Figure 2.

Figure 2

Trend of agriculture land

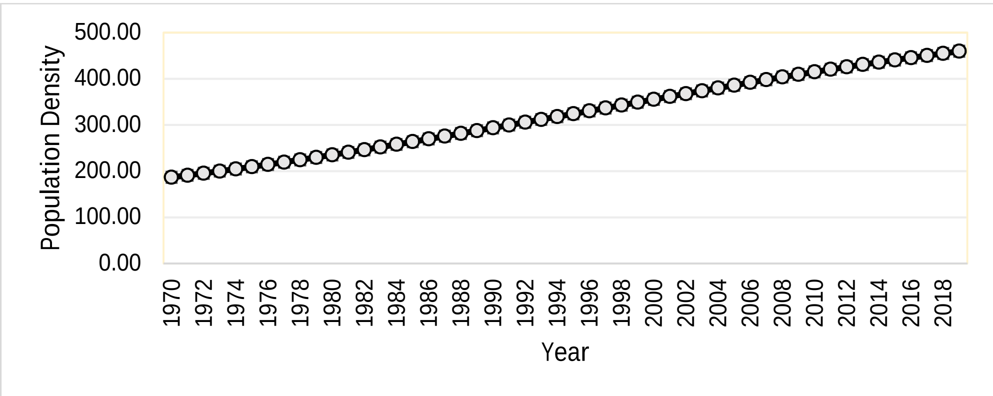


Source: www.data.world.co.in.

According to the Indian Council of Agricultural Research, India is blessed with large arable land with 20 Agri-climate, a wide range of climate conditions and soil types, and can grow different crops. Notwithstanding these realities, the average productivity of many crops in India is very low. India's arable land space of 159.7 million hectares (394.6 million sections) is the second biggest after the United States. Its gross irrigated crop area of 82.6 million hectares (215.6 million sections of land) is the biggest in the world. These lands have a favourable combination of soil quantity, growing season, moisture supply, size and accessibility". The rapidly growing population coupled with enlarged food demand entails either an extension of agricultural land or adequate production gains from current resources (Fitton et al., 2019). The trend of population density is shown in Figure 3.

Figure 3

Trend population density



Source: www.data.world.co.in

Sustainable use of agriculture is essential for economic growth (Hamidov et al., 2016). Land-use changes affect the environmental quality mainly when affected lower-quality lands are environmentally sensitive (Lubowski, 2006). There are severe and rising concerns about the effects of fast population growth on the environment and natural resources, including forests, land, water, biodiversity, and other resources (World Commission on Environment and Development, 1987; Ehrlich, Ehrlich, 1990). The impact of population growth on agriculture and natural resource management has been debated, at least from Malthus (Malthus, 1872). In India, the increase in population size due to unplanned activities, urbanisation is increasing rapidly, which reduces the agricultural land and has a serious impact on the natural resources (Shivani, 2017). Fast populace growth appears to influence the farming area straightforwardly, which upsets the food supply in rural and urban regions. Therefore, food safety and increasing agricultural land losses have become a global concern problem (Oko et al., 2021).

Most of the studies in India are on the economic growth nexus with various variables (for example, Brewer, Boxley, 1981; Mahmood, 2012; Hamidoy et al., 2016; Purnami, Santini, 2017; Hinz et al., 2020). Scant literature was available on economic growth nexus on agricultural land and population density. India is an agrarian economy and stands 2nd in the world population. Seeking for the significant importance of these variables in economic growth, the present study examined the agricultural land and population density linkage with economic growth. The remaining parts of the study are organised as follows: Section 2 discusses the literature review. Methodology and results are discussed in Sections 3 and 4. Finally, the conclusion and policy recommendations are suggested in Section 5.

2. Literature Review

The ample literature was available on the economic growth nexus with various variables. So, in this section, an attempt was made to explore the nexus of economic growth with agricultural land and population density. Lubowski (2006) assessed the association between agriculture land-use changes, soil productivity, and pointers of environmental sensitivity. The results discovered that land moving among cultivated and less intensive agricultural uses is less valuable and more vulnerable to erosion than other cultivated land, both broadly and locally. Sali (2012) investigated the factors responsible for decreasing the amount of agricultural land available in developed countries and explored the negative correlation between GDP and agricultural change to discover the contributing factors behind this decline. Paned data was used in this analysis of the period 1995-2009. The analysis was carried out on a penal of 30 countries with appear middle or high income in the period 1995-2009 period. The study results indicated that the decrease in the cropland that is currently taking place in developed nations is caused by the expansion of forested areas, the urban expansion, and the abonnement of the least productive areas.

Mahmood and Chaudhary (2012) analysed the effect of foreign direct investment on carbon dioxide emissions in Pakistan". It takes carbon dioxide emissions and FDI as a dependent variable, the share of manufacturing value-added, and population density as independent variables. Econometrics tools like ADF, PP, Ng-Perron, Zivot-Andrews unit root test, and ARDL model were utilised in the study. The results showed that the long-run relationship in the model, but the short-run relationship does not exist. FD, manufacturing value-added, and population density have a positive impact on carbon dioxide emissions. Salvati (2013) presented a quantitative evaluation of rural land-use changes in a region devoted to agriculture and experiencing an increasingly higher human effect from urbanisation and land abonnement. The evaluation was carried out at the municipality scale over 40 years (1970-2010) using the national agriculture census data. The results showed how reducing the area devoted to traditional crops and the spreading of high-intensity crops decrease the quality of rural landscapes, especially in areas with a "historical" attitude toward agriculture.

Maletta (2014) analysed the trends and prospects in agriculture and food production related to land & land productivity. He discussed this issue on a global level. Secondary data were used in the study that has been taken from the statistical database complied by FAO. The study found that the world agriculture output, both for food and non-food farm production, has been rising steadily ahead of the population. Also, it reveals that agricultural growth in the past half country, especially in later decades, was primarily due to higher land productivity with just a tiny contribution from additional land. Ohlan (2015) investigated the impact of populace density, energy consumption, economic growth, and trade openness on CO2 emissions in India. The review utilised the yearly data for the period 1970-2013. The autoregressive distributed lag model and vector error correction model were utilised in the study. The study discovered that populace density, energy consumption, and economic growth have a statistically significant positive effect on CO2 discharges both in the short-run and long run. The results also showed that populace density is the primary factor influencing CO2 emissions changes among these three variables.

Nzunda and Midtgaard (2017) analysed the spatial relationship between deforestation and forest protection area, accessibility, human population density, and regional gross domestic product. The period of the study was taken from 1995-2010. The study used the Multiple Linear Regression Model for the statistical analysis. The results of the study indicated that protected areas are essential in reducing deforestation. Higher population density and gross domestic product would be associated with less deforestation if they switched from dependence on wood for various uses and deforestation-based livelihoods. Purnami and Santini (2017) examined the impact of population growth on agricultural land conversion. A sample of 62 farmers was taken in the study to achieve the objective of the analysis. Data obtained from the sample were analysed through the SEM-PLS method. The study found that population growth and agricultural land conversion had a positive and significant effect on the conversion of agricultural land.

Lanz et al. (2017) examined how uncertainty and changeability in agricultural output destroy the capacity to feed a huge, rising, and growing worldwide populace. The study depended on the two-sector Schumpeterian model of growth. They utilise the secondary data for the period 1960-2010. The study discovered that advancement in agriculture innovation is a crucial determinant of sufficient food creation in a world with a rising populace and per-capita income. The results likewise showed that the populace is significantly influenced by variability in TFP (Total Factor Productivity). Reddy and Dutta (2018) investigated the effect of agricultural input use on agricultural gross domestic product. They used the secondary data for the period of 1980-1981 to 2015-2016. A simple regression method was used to assess the impact. The results demonstrated that factors like fertilisers and net irrigated areas are not statistically significant. It implies they do not have a significant effect on agricultural

GDP during the period 1980-2016. Conversely, factors like pesticides, power, precipitation, and seeds significantly affect the agricultural GDP during this period.

Fitton et al. (2019) analysed the potential trends, dangers, and vulnerabilities identified with land use and land accessibility that might arise from reducing water accessibility. The results demonstrated that around the world, 11-10 percent of crops and gross land can be vulnerable to a decrease in water accessibility and may lose some functional, productive capacity. Lessening farming regions related to dietary changes offer the most significant buffers against land loss and food instability. Apata et al. (2019) studied the connection between the agricultural land-use system and climate change. For this purpose, the farm-level cost-route survey of cross-sectional data of 800 respondents was used. The data were analysed by using statistical tools and techniques like the trilogarithms model and multivariate probit model. The study results indicated a strong relationship between efficient use of agricultural land adaptive processes to climate change. Hinz et al. (2020) assessed the pathways of agricultural productivity, land use, and land cover changes in India and their effect on earthbound biodiversity and carbon stockpiling. The results showed that it is essential that the agricultural lands will probably grow, and existing farmlands need to be strengthened to meet the future food production demands.

Considering the review above, there is a need to work on the interaction of agricultural land and population density with economic growth. Thus, this paper has made an attempt to investigate the association between agricultural land, population density, and economic growth in India.

3. Data and Methodology

3.1. Data

Gross Domestic Product (GDP), Agricultural Land, and Population Density of India are retrieved from World Data Indicators (WDI). The yearly data for the period 1970-2019 is selected for the analysis. The measurement units of data are given below in Table 1.

Table 1

Variables Description

Variable	Symbol	Measurement
Gross Domestic Product	GDP	“Constant 2010 US$, Per Capita”
Agricultural Land	AL	“Percentage of Land Area”
Population Density	POP	“People Per Square Kilo Meter of Land Area”

Source: www.data.world.co.in.

3.2. Econometric Model and Methodology

3.2.1. Unit root test

In the first phase, Augmented Dickey-Fuller (ADF) was used to determine the stationarity of the data set. A null hypothesis is set, H_0: $Series\ has\ a\ unit\ root$, i.e., series is non-stationary (Dickey, 1981). So, the subsequent equation is set:

$$\Delta Y_t = \alpha_1 \beta_0 \beta_1 + \beta_{AL} AL_t + \beta_{POP} POP_t + \mu_t \quad (1)$$

Where Y_t, AL_t, POP_t and μ_t are Gross Domestic Product, Agricultural Land, Population Density and μ_t the error term.

3.2.2. Johansen co-integration

The co-integration test assists in the confirmation of the null hypothesis $[H_0: There\ is\ no\ co - integration]$ (Johansen, 1988). The Trace test and the maximum eigenvalue test are the two components of the Johansen co-integration tests.

$$LR(r_0, n) = -T \sum_{k=r_{0+1}}^{n} In\,(1 - \lambda_i) \quad (2)$$

$$LR(r_0 + r_0 + 1) = -TIn(1 - \lambda r_0 + 1) \quad (3)$$

3.2.3. Vector error correction model (VECM)

The third stage will allow for investigating both the short-run and long-run behaviours of co-integrated patterns (Engle, 1987). The standard ECM for the co-integrated sequence is:

$$\Delta GDP_t = \alpha_0 + \sum_{k=1}^{n} \beta_i\, \Delta GDP_{t-i} + \sum_{k=0}^{n} \delta_i \Delta_{t-i} + \varphi z_{t-1} + \mu_t \quad (4)$$

$$\Delta AL_t = \beta_0 + \sum_{k=1}^{n} \alpha_i\, \Delta AL_{t-i} + \sum_{k=0}^{n} \delta_i \Delta GDP_{t-i} + \varphi z_{t-1} + \mu_t \quad (5)$$

$$\Delta POP_t = \beta_1 + \sum_{k=1}^{n} \beta_i\, \Delta POP_{t-i} + \sum_{k=0}^{n} \delta_i \Delta GDP_{t-i} + \varphi z_{t-1} + \mu_t \quad (6)$$

Where, z is the ECT (Error Correction Term), and the OLS (Ordinary Least Square) residual from the subsequent long-run co-integrating regression: $GDP_t = a_0 + a_1 GDP_t + \mu_t,\ AL_t = \beta_0 + \beta_1 AL_t + \mu_t$ and $LPOP_t = \beta_1 + \beta_2 POP_t + \mu_t$ are defined as $z_{t-1} = ECT_{t-1} = GDP_{t-1} - \beta_0 - \beta_1 AL_{t-1} - \beta_1 - \beta_2 POP_{t-1}$. To confirm the VECM outcomes, a conventional Granger Causation Test is used that checks the causality flow direction from one component to another and conversely (Granger, 1969). The Granger causality test model equation:

$$\Delta GDP_t = \alpha + \sum_{i=1}^{k} \beta_i\, \Delta GDP_{t-i} + \sum_{i=1}^{k} \psi_i \Delta AL_{t-i} + \sum_{i=1}^{k} \psi_i \Delta POP_{t-i} + \mu \quad (7)$$

$$\Delta AL_t = \beta_0 + \sum_{i=1}^{k} \beta_i\, \Delta AL_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta GDP_{t-i} + \sum_{i=1}^{k} \psi_i \Delta POP_{t-i} + \mu \quad (8)$$

$$\Delta POP_t = \beta_1 + \sum_{i=1}^{k} \beta_i\, \Delta POP_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta GDP_{t-i} + \sum_{i=1}^{k} \psi_i \Delta AL_{t-i} + \mu \quad (9)$$

Whereas α, β, ψ, and γ are component to be projected and μ signify the serial error terms, $GDP_t\ AL_t, and\ POP_t$ are specified adherence for the t periods; Δ is the variance operator; k mentions to the lag numbers; α, β, ψ, and γ all are the assessment factors.

4. Results and Discussion

4.1. Descriptive Statistics

Table 2 exhibits the summary numbers of included variables, namely economic growth, agricultural land, and population density. The mean of economic growth is the highest (860.7222) and the lowest is for the agricultural land (60.62765). The standard deviation of the agricultural land is the lowest among all studied variables. The skewness of the economic growth and population density is positive while negative for the agricultural land. It implies that agricultural land has the option of negative earnings. All variables' series are normally distributed as p-value is greater than 5 percent.

Table 2

Descriptive statistics of Variables

Statistics\Variables	GDP	AGL	POP
Mean	860.7222	60.62765	322.1097
Median	656.9442	60.66915	321.1238
Maximum	2151.726	61.07447	459.6329
Minimum	381.5396	59.80681	186.7320
Std. Dev.	509.6078	0.310281	84.78097
Skewness	1.091121	-0.707739	0.017486
Kurtosis	3.074501	3.321711	1.707492
Jarque-Bera	9.932772	4.389743	3.482915
Probability	0.126968	0.111373	0.175265
Sum	43036.11	3031.382	16105.48
Observations	50	50	50

Source: Author's Calculation.

4.2.2. Unit Root Test

There is a requirement for data series to be stationary in the analysis. The outcomes of the unit root test are shown in Table 3. For stationary analysis, an increased Dickey-Fuller (ADF) test is used. The table revealed that at first difference, all variables' p-value is less than 5 percent which indicates the decision of rejection of null hypothesis H0: series has unit root or not stationarity. The results indicate that series are integrated at I (1).

Table 3

Unit-Root Test (Augmented Dickey-Fuller)

Variables	ADF Statistics	First Difference (P-Values) *
GDP	-4.954348	0.0011
AGL	-8.086072	0.0000
POP	-3.160874	0.0291

Source: Author's Calculation.

The findings show that I (1) series are integrated. However, the appropriate lag length or number of lags in Vector Auto-regression (VAR) must first be selected before the Johansen co-integration and the VECM analysis. The various lag values showing the log L, LR, FPE, AIC, SC, and HQ are presented in Table 4. In all cases, however, lag 2 had a significant value. Thus, 2, the appropriate lag duration, may be calculated and is utilised for subsequent studies analyses.

Table 4

Result of Lag Length Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-595.0625	NA	13331744	24.91927	25.03622	24.96347
1	-125.1230	861.5559	0.060870	5.713456	6.181257	5.890239
(2)	-60.66153	110.1216*	0.006068*	3.402564*	4.221214*	3.711933*

* Indicates lag order, LR- sequential modified LR test statistics (each test at 5% level, FPE- Final prediction error, AIC- Akaike's information criterion, SIC- Schwarz information criterion, HQ-Hannan Quinn information criterion".

Source: Author's Calculation.

4.3. Johansen Cointegration Test

After knowing that all variables are stationary and integrated at I (1); further the Johansen Cointegration test is run. Johansen's test has further two tests that are Trace test statistics and Maximal eigenvalue statistics. The null hypothesis of this test is H0: There is no co-integration in series. Table 5 discloses both tests result. The values shown for the hypothesised number of co-integrated equation none, at most 1 and at most 2, both trace and eigenvalue statistics reject the null hypothesis as obtained statistics values for all is greater than its critical values at 5 percent. The results indicated that at most 2 vectors could be formulated. So, this test confirmed the presence of long-run association among variables series.

Table 5

Johansen Cointegration Test

Trace Test Statistics				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.683162	74.71081	28.87707	0.0000
At most 1*	0.264742	20.69074	15.49471	0.0075
At most 2*	0.124268	6.236674	3.831466	0.0125
Maximal Eigenvalue Statistics				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.683162	54.02007	21.13162	0.0000
At most 1*	0.264742	14.45406	14.26460	0.0467
At most 2*	0.124268	6.236674	3.831466	0.0125

Note: Trace test statistics and Max-eigenvalue test indicate 3 co-integrating eqn(s) at the 0.05 level, *denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values".

Source: Author's Calculation.

4.4. Vector Error Correction Model

As specified in the results of the Johansen co-integration test, the VECM test has to perform to study the long-run relationship and how the divergence of variables is corrected. The analysis of VECM is disclosed in Table 6, along with the coefficients, t-statistics, and p-value. In this study, economic growth is the dependent variable and agricultural land and population density are explanatory variables. Both long-run and short-run effects are enclosed by the VECM test. The ECT and adjustment speed came out to be -0.110743 with significant t-statistics value. This negative and significant value satisfied the condition of continuation of the long-run relationship among variables.

The negative value (-0.110743) specified that prior period divergence in the variables is corrected at a speed of 11 percent in every year. It indicates when the co-integrated series experience the disequilibrium; GDP modifies itself and maintains equilibrium. Observing lagged value of studied variables, at lag one values of GDP and POP is significant, which indicates the presence of short-run causality moving towards GDP. On the other hand, at both lags, the agricultural land coefficient is insignificant, which specified the short-run causality absence from AGL towards GDP.

Table 6

Vector Error Correction Model

Dependent Variable →	D(GDP)		
	coefficient	t-statistics	p-value
Cointeq1	-0.110743	-2.575274	0.0139
D (GDP (-1))	0.324585	2.097324	0.0425
D (GDP (-2))	0.103605	0.679141	0.5011
D (AGL (-1))	-23.57923	-0.768529	0.4468
D (AGL (-2))	-5.371277	-0.191183	0.8494
D (POP (-1))	-99.29204	-1.701489	0.0968
D (POP (-2))	33.66858	0.499474	0.6203
C	391.6578	2.899656	0.0061

Source: Author's Calculation.

Further, with the help of the Wald Test existence of a short-run relationship is verified whether jointly POP (-1) and POP (-2) granger cause the GDP or not. The null hypothesis POP (-1) = POP (-2) = 0 was evaluated using the Wald Test for POP (-1) and POP (-2) coefficients. The null hypothesis is rejected because the p-value (0.0014) for this chi-square statistical is less than 5 percent, according to the data in Table 7. As a result, it is possible to conclude that there is short-run causation between POP and GDP.

Table 7

Wald Test

Test Statistic	Value	Degree of Freedom	Probability
F-statistic	6.557487	(2, 39)	0.0035
Chi-square	13.11497	2	0.0014

Source: Author's Calculation.

To check the fitness model parameters, there is a need to perform the serial correlation test. This test helps in verifying the absence the serial correlation among variables under study. The serial correlation of Breusch and Godfrey in residual diagnostic, the LM test is chosen by identifying two lags (Table 4). The null hypothesis was H0: there is no serial correlation. The results presented in Table 8 indicated that the null hypothesis could be ignored since the p-value is more significant than 5 percent based on the prob. chi-square value (0.1958). As a result, there is no indication of serial correlation across components, which is a positive indicator for the model.

Table 8

Breusch-Godfrey Serial Correlation LM Test

F-statistic	Obs* R-squared	Prob. F (2,37)	Prob. Chi-Square (2)
1.379336	3.261114	0.2644	0.1958

Source: Author's Calculation.

The CUSUM and CUSUM Square tests are used to determine the validity of the model constants. Figure 4 and Figure 5 show the plot of both tests. Both figures depict the blue line for model constants are within the limits of 5 percent significant level, which verifies that variables are stable and consistent.

Figure 4

CUSUM Test

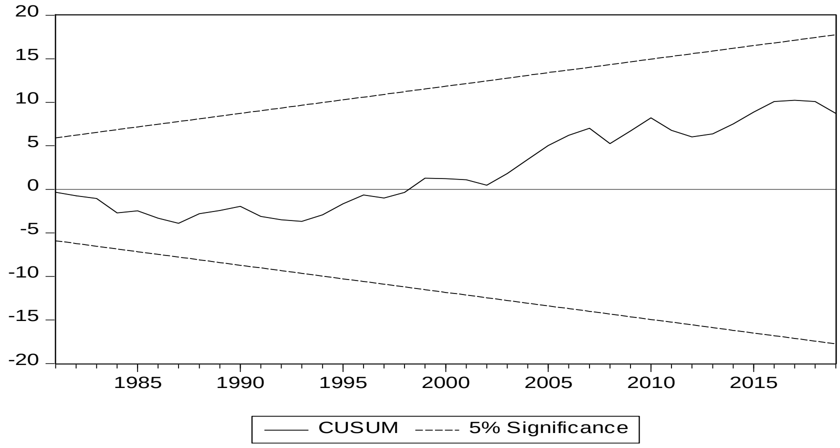
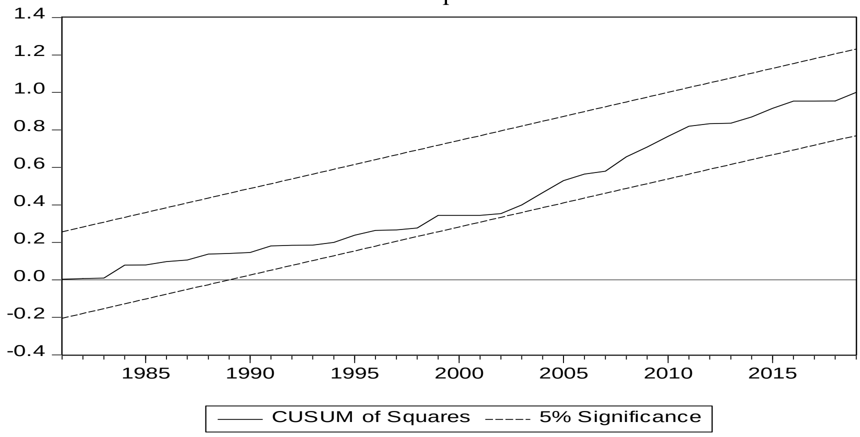


Figure 5

CUSUM Square Test



4.5. Pairwise Granger Causality Tests

The Pairwise Granger Causality test was used to confirm the VECM results. This test facilitates the verification of the long-run and short-run causal connections between variables. The results are presented in Table 9. Based on f-statistics table revealed that AGL and GDP does not granger cause each other as p-value is greater than 5 percent significance level. Observing the causal relationship between POP and GDP, it suggested the bi-directional causal relationship between POP and GDP. Thus, it supports the feedback hypothesis and confirms the results of VECM analysis and Wald test (Table 7 and Table 8). Further, the table shows that null hypothesis H0: POP does not granger causes AGL, is rejected as p-value is less than 5 percent. This directs to the decision that changes in POP cause changes in the AGL.

Table 9

Pairwise Granger Causality Tests

Null Hypothesis:	F-Statistic	Prob.
AGL does not Granger Cause GDP	0.19532	0.8233
GDP does not Granger Cause AGL	1.66655	0.2009
POP does not Granger Cause GDP	3.30069	0.0464
GDP does not Granger Cause POP	3.83334	0.0294
POP does not Granger Cause AGL	3.26722	0.0478
AGL does not Granger Cause POP	2.27646	0.1149

Source: Author's Calculation.

4.6. Variance Decomposition Analysis

Further, the present study performed the VDC for a detailed understanding of the relationship among variables. The findings are exhibited in Table 10. The table demonstrates that in the first period, economic growth explains 100 percent variations itself. In a short period, 85 percent of variations are due to the GDP itself and 14 percent is described by the POP. In the long run, i.e., in period 20, POP explained the around 12 percent variability in GDP while AGL explained only 1.43 percent.

Considering the forecasted error variance of AGL, the table showed that an 88 percent variation in AGL is produced by the AGL itself in the short run from 1 to 5 periods. In the long run, the study found that variance error in AGL is explained by itself around 18 percent, and the most significant variance error is come out to be from economic growth that is 72.48 percent. Regarding variance decomposition of POP, 75 percent of shocks is explained by POP itself in first period. In the long-run period Agricultural land contribution is slightly 8 percent, while GDP causes the highest variation, that is 74.87 percent in POP.

Table 10

Variance Decomposition

Variable	Period	S.E.	GDP	AGL	POP
GDP	1	18.98976	100.0000	0.000000	0.000000
	5	61.72369	91.23599	3.122957	5.641050
	10	148.5493	85.08232	0.908516	14.00917
	15	254.7994	85.74372	1.323320	12.93296
	20	332.7605	86.80778	1.427798	11.76442
AGL	1	0.089797	3.953143	96.04686	0.000000
	5	0.110531	11.47477	88.45129	0.073939
	10	0.136015	23.75639	76.02557	0.218033
	15	0.184832	49.43069	46.31831	4.251008
	20	0.294007	72.48104	18.45573	9.063233
POP	1	0.015931	23.39519	0.906537	75.69827
	5	0.393381	53.98045	4.633639	41.38591
	10	1.878888	67.52774	7.238633	25.23363
	15	4.131874	72.53774	7.874409	19.58785
	20	6.500451	74.87460	8.006119	17.11928

Source: Author's Calculation.

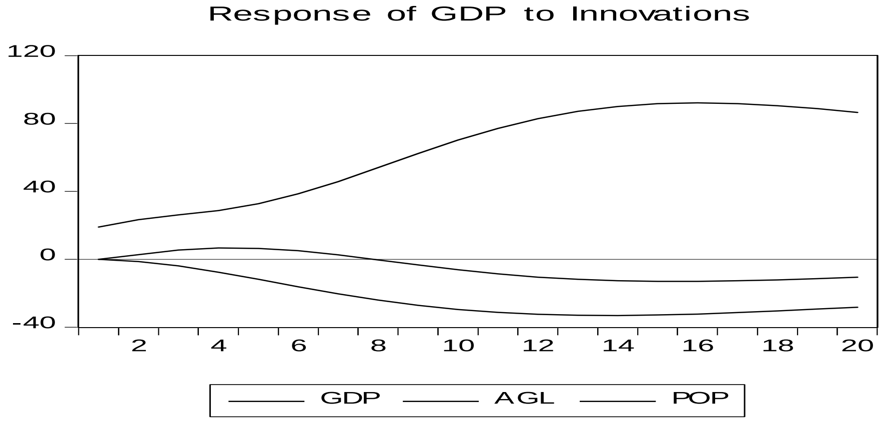
4.7. Impulse Response Function

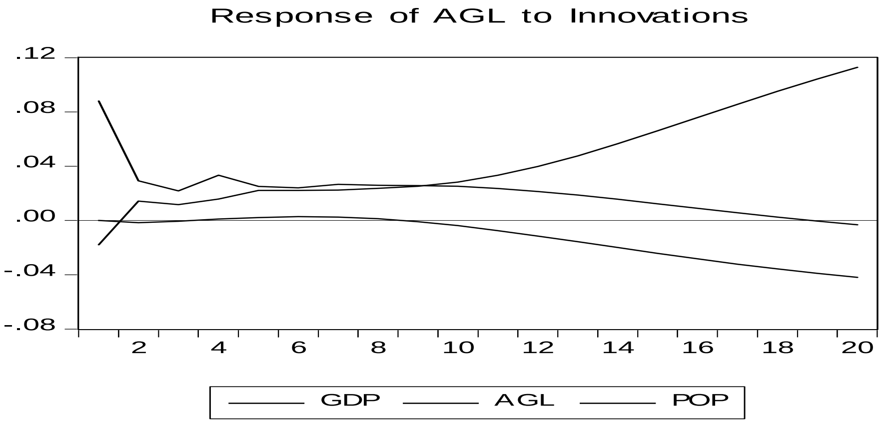
In addition to the variance decomposition analysis, the current study also applied the Cholesky Impulse Response Function (IRF). The IRF shows the innovation response of explanatory variables in the target variable by graphical representation. The IRF of each variable is shown in Fig. 6. First, the response of agricultural land to a shock of economic growth shows that it starts from zero and moves positively till period 10. Then after period 10 it becomes negative in the long run. The impulse response of population density reveals that it remains negative in the whole period.

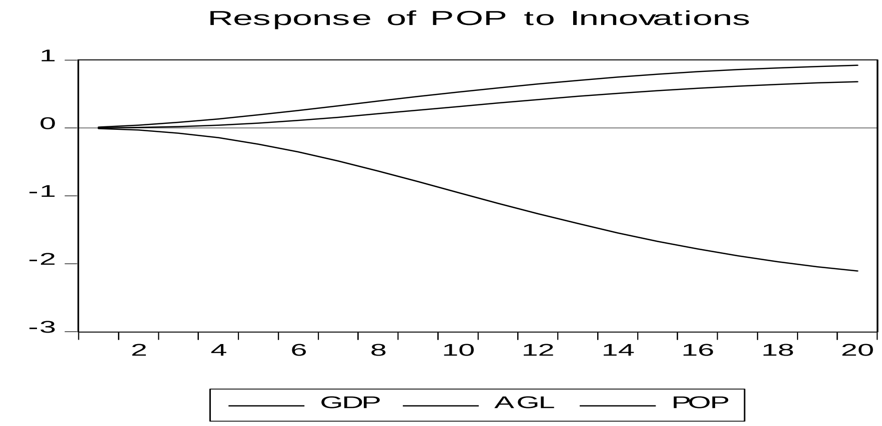
Observing one standard deviation response of agricultural land to innovations reveals that in the beginning, GDP is negative, but suddenly it becomes positive and remains to stay positive till period 10. After period 10 it moves positively in an upward direction. The population density response towards agricultural land shows that till period 10 it moves along with zero lines, then it becomes negative and finally. The growth feedback response to population density shows that one standard deviation disturbance in POP will negatively impact the growth. Response of agricultural land to POP shows that it begins from zero and moves positively after period 2. Then, in the long run, it increases and moves in a positive direction. Finally, it disappeared with the time horizon. Due to the rapid increase in the population in India, the size of land holdings continues to decline. Around 82 percent of farmers are small and marginal in India (FAO). Therefore, people are moving towards the industrial and service sector from agriculture. That is the primary reason behind the declining share of agriculture in the GDP of India continuously since independence.

Figure 6

Impulse Response Function







5. Conclusion and Policy Recommendations

Looking at the significance of the variables in the economic growth, the present study examined the linkage between agricultural land, population density, and India's economic growth. Further, the variance decomposition (VDC) and impulse response function (IRF) was employed for a detailed explanation of the variables' relationship and innovation responses of explanatory variables. The Granger causality test results suggested that agricultural land and the gross domestic product have a neutral relationship (studies results consistent with Lubowski, 2006; Fitton et al., 2019). The population density and gross domestic product support the feedback hypothesis (studies results consistent with Sali, 2012; Fitton et al., 2019; Hinz et al., 2020). Further, population density affects agricultural land (studies results consistent with Purnami and Santini (2017), Digha, 2018), whereas agricultural land does not affect population density (studies results consistent with Lubowski, 2006; Purnami, Santini, 2017; Digha, 2018; Fitton et al., 2019). As a result, population density is significant in nations that specialise in resource development and farming.

From a policy viewpoint, the policymakers should make efforts and frame strategies to decide the comprehensive significance of population density in the nation. In harvesting economies, such as those reliant on agriculture and food security, population size is critical. Overcrowding reduces environmental resources per capita, but it facilitates infrastructural improvement, resulting in the ideal population density for growth in the economy. The appropriate size of a country can also be influenced by population density. While there are numerous other variables to consider, geographical organisation is also critical. A country's land area is seen as a form of capital that generates revenue from resource utilisation. The first sort of cost is the distance of a border, which necessitates protective measures. Another expense is commuting to and from the capital, and population density also has a role here.

The present study also has certain limitations. The study was based on aggregate level data as disaggregate level data was not available. In the future, a panel study of disaggregated level data can be analysed in various states or on a multi-country basis. Recent techniques can be applied over the disaggregate level data like autoregressive distributed lag (ARDL), panel data, quantile regression, and time series analysis. Moreover, additional variables like energy as input in agriculture, energy prices, and agricultural production at a disaggregated level can be studied along with economic growth.

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