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Factors Influencing Sustainable Agricultural Development in Bihar

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Abstract: This paper examines the factors influencing the sustainable growth of agricultural value-addition based on time series data of Bihar over the period 1990-2021. The results indicated that there are significant and certain benefits from the utilization of a system of technological innovations including mechanization, renewed capital stocks, as well as temporary annual cropping, and permanent cropping practices. Farming practices involving crop rotation, multi-cropping, and agroforestry are recommended for sustaining agricultural sustainability since they seem to be economically viable and environmentally friendly. It was found that technological innovations in soil conditions, irrigation systems, and chemical fertilizers might be beneficial to agricultural productivity growth in the long term when they are managed by soil characteristics and in a balanced way. The results also showed that the labor force, the forest area, the number of credits to agriculture, and the amount of energy consumed to power irrigation are likely to be insignificant to boost directly the growth of agricultural value-added. Thus, the various issues raised in the process of using all agricultural technologies must be addressed either by policy or by appropriating the knowledge relating to their management to make them more profitable to agricultural economic growth.

Keywords: Sustainable Economic Growth; Agricultural technology; Cobb-Douglas production function.

JEL Classification: Q01; Q16; C67.

INTRODUCTION

The agriculture & allied sector is one of the most vibrant sectors of the Indian economy that accounts for nearly one-sixth of the national income and employs half of the country's workforce. It remained a rare bright spot even in the ailing economy due to the Covid-19 pandemic. Significant growth in agriculture production in India led to national food security and helped in reducing poverty. But the rapid population growth coupled with the shift in consumer preference towards high-value products after rising urban income enforces the burden on shrinking natural resources and induces an increase in the cost of cultivation, which has wedged the profitability, and farming is not considered a fair option of livelihood. Depletion of natural resources, tepid growth in income, and imperfection in input and output have enhanced the vulnerability of the Indian farm sector. Thus Indian agriculture faces the twin challenges of improving productivity to ensure profitability in farming on one hand and maintaining resource sustainability on the other.

Agriculture, Forestry, and Land-use play a key role in meeting the environmental, economic, and social dimensions of Sustainable Development Goals, providing livelihood support to about seventy percent rural population in low-developed countries like India and providing a key contribution to poverty reduction with GDP growth originating in agriculture being two times more effective in reducing poverty than GDP growth outside agriculture (World Bank, 2008). However, agriculture displays a complex linkage with climate change contributing to one-third of Global Greenhouse Gases emissions, but also negatively impacted climate change which has direct & indirect, tangible & intangible effects, and long-term consequences. The Climate Smart Agricultural Approach has provided the answer to complex relationships between agriculture, food security policy, and climate by adopting mitigation and adaption measures to curb CHG emissions linked to agriculture, waste, and pollution based on sustainable agricultural intensification for food security, resource, and resilience.

Agriculture can play a key role to ensure food security while contributing to tackling climate change. Given the complexity, multidimensionality, and uncertainty that characterize agricultural eco-systems, and interdependencies between the actors and sectors which characterize the Climate Smart Agricultural Approach (the World Bank, 2011), to access the impact of the food system on sustainability, we need to construct a model that could take account of the complex system characterized by non-linearity, multiple feedbacks, time delays, non-rational, short –term thinking and free-riders agents.

2. SUSTAINABLE DEVELOPMENT

2.1. Meaning

Sustainable development is a development that ensures the balance between the three aspects: social, economic, and environmental. In recent years, environmental issues, as well as issues of social and economic inequality and well-being, raise a growing concern in the world. Sustainable development also implies the quality of education, health, and infrastructure, the satisfaction of basic needs, and the provision of energy efficiencies through economic growth. Sustainable development issues are closely related to problems such as population growth, rapid urbanization, food security, water scarcity, energy supply, climate change, and resource shortage. All these aspects have a close linkage with the reduction of unemployment and with the reduction of inequality has the potential to contain inflation effectively.

2.2. Development Scenario in India

India conceptualized the need for planned development after independence and has achieved self-sufficiency in many fields including food through several massive river projects, industrial townships, and special economic zones. But many social, economic, and natural forces are causing widespread damage & destruction - which compels us to rethink the concept of development. United Nations(1987) took the lead to globalize the concept of development through the introduction of Sustainable Development, which was introduced to meet the needs of the present without compromising the ability of the future generation to meet their own needs. The United Nations(2015) has adopted seventeen Sustainable Development Goals- of which fourteen are human development goals and three are environmental protection goals. India has not structured a system to thoroughly access its position to systematically proceed with its action plan to achieve the seventeen sustainable development goals adopted by the United Nations. The position of India in respect of some of the major goals as indicated below are not encouraging:

1. Poverty: Economic Survey (2017) admits that rural poverty is high and Bihar, Jharkhand & U.P are the poorest states.
2. Hunger: The 2021 Global Hunger Index ranks India 101st among the 116 countries, which indicates that food security has still not been achieved.
3. Good Health & Well-Being: India ranked 65 out of 195 countries in the Global Health Security Index (2021).
4. Quality Education: India ranks 32 on Education in the World Population Review Educational Ranks of countries (2022). The Indian Education System suffers from major inequalities in education, employment, and income. Steep drop-out rates in primary and middle schools impede education.
5. Gender Equality: The lack of data on gender equality jeopardize the agenda. Though India has empowered women in the Panchayati Raj Institutions the women in PRI suffer problems. India has slipped 41 places in the Global Gender Gap report, 2021.
6. Decent Work & Economic Growth: Unemployment is a major problem in India.

India has still to begin its systematic planned journey toward achieving sustainable development goals.

2.3. Agricultural Perspective

India's population is growing at a level where the population supporting capacity of major ecosystems is being exceeded and in the future, India will have no option but to produce more food, fiber, fodder, and all other commodities under the condition of diminishing per capita availability of arable land and water. As water is becoming a serious limiting factor, not only for agriculture and ecosystem maintenance but also for domestic consumption - an ecological dimension to the concept of food security has become an urgent task, since the traditional agricultural practices may lead to an era of agricultural disaster rather than an era of agricultural prosperity. Swaminathan(1981) elaborated that the steps for achieving ecological security would include measures of protecting the basic assets of agriculture and minimizing the liabilities. This can be achieved through the appropriate analysis, public policies, land, and water use practices that are compatible with the concept of sustainable development - which has to be joint sector activities involving the people and the government.

The Agriculture & Allied Sector in India is the backbone of rural livelihoods security systems, but its contribution to the Gross Domestic Product has been steadily declining over the years though the share of agriculture providing employment and livelihood has been static. Thus the onus of providing employment and livelihood to a majority of the population remains with agriculture and is the safety net against hunger and poverty- the two key agendas of sustainable development adopted by the United Nations. Indian agriculture is not only an instrument for providing food but is a major source of livelihood opportunities.

Sustainability in agriculture means that land and resources in present use will be handed over to future generations without any systematic deterioration so that they could continue the agricultural practice and have food security. This implies efficient utilization of resources without imbalance or polluting the environment through ecologically sound, economically viable, socially just, and human. India achieved a double-digit increase per year in agricultural production after its independence and to meet the growing needs of its expanding population is expected to produce 210 million tons of food grains per year by 2050 if the present growth of the population perpetuates. India is currently in a comfortable position of food grains production due to the use of a high-yielding variety of seeds, but intensive use of land without taking enough care to maintain its production capacity leads to loss of topsoil due to erosion, loss of organic matters, loss of porous soil structure and waterlogging, and built up of toxic salts and chemicals. Deficiencies of micronutrients such as zinc, iron, and manganese have also increased in soil. Overuse of pesticides has caused localized health hazards. Indiscriminate use of modern agricultural technology may endanger ecological security and imbalance the environment. Indian agriculture faces problems related to sustainability, viz., marked deterioration of renewable resources and environment, and leveling of agricultural yield despite doses of new inputs and high-yielding technology.

Food security for the 1.5 billion population involves an adequate increase in food production, growing employment in rural and urban areas, and provision of basic amenities such as safe drinking water and primary health care, and all of these constitute economic development. Many feared that environmental protection might harm rapid economic development. But protecting the ecological base is extremely important for food production and livelihood access. A balance between present security and future sustainability is important. The goal of food security (food production, employment generation, and provision of basic amenities and health care) should be pursued and achieved through the sustainable use of environmental resources.

3. PURPOSE OF THE STUDY

This study analyses the influence of technologies in value addition that contribute toward the compilation of the gross domestic product from agriculture with prominent subsistence farming to facilitate potential changes in the income structure in Bihar. It is important to investigate how the range of agricultural technologies like mechanization, chemical technology, management practices, and policies relating to cropping, as well as other agricultural infrastructures, could improve value addition to the gross domestic product besides the common factors of production (capital stock, labor force, land area). The main issues investigated are: How are agricultural technologies linked to the agricultural production growth and what association of agricultural technologies should be deployed for sustaining the growth of the agricultural gross domestic product in Bihar.

This study depends on the Cobb-Douglas (C-D) production function to determine the influence of agricultural technologies on the growth of agricultural value-added in India over the period 1990-to 2021. Then, an analysis is made of the response to agricultural value-added growth over time following technological innovations or shocks.

4. MODELING

Cobb-Douglas (C-D) production function, may be written as:

$$Y = A_0 \exp(\delta t) \prod_{i=1}^{p} X^{\alpha_i} \quad (1)$$

where Y is the potential output or income value A_0 is the level of the output at the base period, *exp* represents the exponential function, δ is the parameter of technological progress, t indicates the time variable expressing the influence of technological progress,

p is the number of factors of production, X is a matrix of factors of production and α_i is the parameter of ith factor of production.

It may be mentioned that the α_i are the output or income elasticity coefficients. With the partial derivative on X in Equation (1), we can get:

$$\frac{\partial Y}{\partial X_i} = \alpha_i \frac{Y}{X_i} \tag{2}$$

Hence,
$$\alpha i = \frac{\partial Y}{\partial X_i} \times \frac{X_i}{Y}. \tag{3}$$

X_i is the *ith* factor of production. The values of the α_i are obtained by applying the logarithm on both sides of equation (1). Thus, the basic specification is given as follows:

$$\ln(Y) = \ln(A_0) + \delta t + \Sigma_{i=1}^{p} \alpha_i \ \ln(X_i), \tag{4}$$

Where $ln(Y)$ is the logarithm of the dependent variable. Moreover, the contribution rate in percentage of a factor of production to the growth of output or income may be calculated by the following equation.

$$E_{X_i} = \alpha_i \frac{g_{X_i}}{g_Y} \times 100 \tag{5}$$

where E_{X_i} and g_{X_i} are respectively, the contribution rate and the average annual growth rate of the *ith* factor of production; and gY is the average annual growth rate of the output or income.

5. DATA

The dataset comprises one endogenous variable Agricultural value-added and nine exogenous variables: Net capital stock; Number of machines (tractors, harvesters, threshers) used; Amount of credit to agriculture; Energy used to power irrigation; Number of workers in the agriculture sector; Area of arable land and permanent crops; Area on planted and naturally regenerated forest; Area equipped for irrigation; Amount of chemical fertilizers consumed. These variables comprise part of the official statistics compiled regularly by the various government agencies and were obtained from the concerned Department of the Government of Bihar. The modeling adopted is based on annual time series data for 31 years (1990-2021) on these ten variables. Table 1 provides variable definitions and data sources.

The data were examined for stationary time trend with the null hypothesis of the Augmented Dickey-Fuller t-test:

$H_0 : \theta = 0$ (i.e. the data need to be differenced to be stationary)

Versus the alternative hypothesis of

$H_1 : \theta < 0$ (i.e. the data are stationary and do not need to be differenced)

Data were processed through suitably developed R- Programming.

Table 1: Variable definitions and data sources

Variable	*Definition*	*Sources*
AGRIVA	Agricultural value-added (Rs crore, value price)	DES, Bihar,
NETK	Net capital stocks value (Rs crore, value price)	Author estimate,
MACHI	Number of machines (tractors, harvesters, threshers) used	DES, Bihar,
CREDI	Amount of credits to agriculture (Rs crore, value price)	NABARD,
ENERG	Amount of energy used to power irrigation, in Million Kwh	Govt. of Bihar,
LABOR	Number of workers in the agriculture sector	DES, Bihar,
ALAND'	Number of hectares of land for arable & permanent crops	DES, Bihar,
FORES	Number of hectares of land for planted & naturally regenerated forest	DES, Bihar,
IRRIG	Number of hectares of land equipped for irrigation	DES, Bihar,
FERTIL	Number of tons (quantity of fertilizer consumed) for chemical fertilizers (nitrogen, phosphorus, and potassium) consumed	DES, Bihar,

6. DESCRIPTIVE STATISTICS

Table 2 describes variables (in logarithm) in terms of central tendency and dispersion. Throughout the study, the average value-added is about Rs 3228 billion, almost identical to the average value of net capital stocks. The discrepancy between the maximum and minimum values of each variable is likely to be insignificant except for *FERTIL* as is shown in Fig. 1.(b). The statistics show with exception of *IRRIG* and *FORES* of which the Mean values are greater than the Median values, that all other variables are negatively skewed. In addition, it is found that all variables show a leptokurtic tendency given that their kurtosis coefficients are positive. The statistics also inform about a normal distribution regarding all variables except *CREDI* and *FERTIL*.

Figure -1(a) and Figure 1(b) describe the trend of the annual growth rate of variables. It indicates that the evolvement of variables has not been steady over the study period. The trends depict serious fluctuations in the growth rate of agricultural technologies and as a result, an unstable growth rate of agricultural value-added. In 2005 and 2010 [Fig. 1-(a)], the growth of agricultural value-added was negative, showing a certain drop in the value-added with a slight severity in 2010. The highest growth rate is about

Table 2: Descriptive Statistics of Variables*

	LAGRIVA	*LNETK*	*LMACHI*	*LCREDI*	*LENERG*	*LLABOR*	*LALAND*	*LFORES*	*LIRRIG*	*LFERTIL*
Mean	13.24	13.22	5.26	8.34	3.93	7.34	7.85	8.51	2.71	9.26
Median	13.32	13.25	5.28	8.69	3.97	7.42	7.88	8.62	2.77	10.17
Max.	14.25	14.32	6.78	9.68	4.79	8.24	8.87	9.42	3.81	12.22
Min.	8.32	7.56	4.32	6.75	2.87	6.97	7.13	8.06	1.17	3.61
Stan Dev.	0.34	0.11	013	2.15	0.01	0.14	0.21	0.09	0.37	1.89
Skewness	-0.31	-0.15	-0.03	-2.34	-0.22	-0.52	-0.82	0.12	0.10	-1.64
Kurtosis	1.85	1.25	1.84	9.64	1.05	2.31	2.22	1.87	1.18	4.80
Jarque-Bera	1.92	3.53	1.51	74.47	4.50	1.78	3.77	1.50	3.75	15.77
Prob.	0.38	0.17	0.47	0.00	0.10	0.41	0.15	0.47	0.15	0.00
Sum	357.06	356.68	142.13	225.15	106.70	198.08	211.80	229.70	73.18	248.30
Sum of square	3.09	0.29	0.41	118.29	0.01	0.43	1.20	0.21	3.58	92.83
No. of Observ.	31	31	31	31	31	31	31	31	31	31

L:*indicates the logarithm of AGRIVA and all other variables are described in logarithmic values as well.

16.5% (2003) and attained by *IRRIG* whereas the lowest growth rate is about -6% (2006) and attained by *ALAND*. Figure 1-(b) presents information specific to the growth rate trend of chemical fertilizers uptake, of which the peak is attained at 19.42%. This evolution raises some questions about the effect of chemical technologies on crop yields. However, studies have suggested that applying chemicals in a balanced ratio would be the best way to draw profit from these land-saving technologies (Roberts, 2007). Figure 1- (a) shows trends of annual growth rates of agricultural value-added, net capital stocks, machinery, arable land, permanent crops, and an area equipped for irrigation (1990-2020).

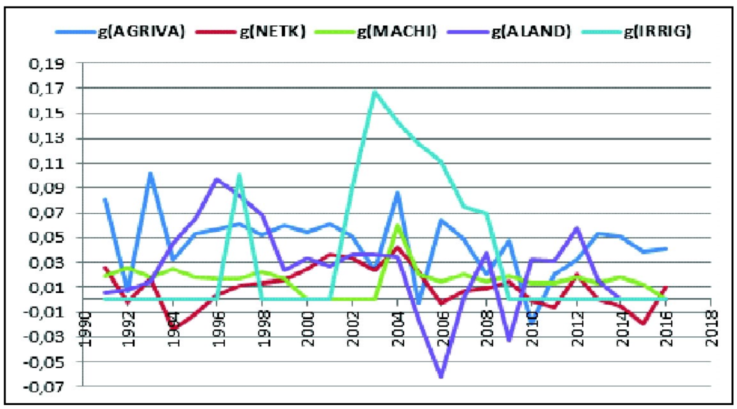


Figure 1-(a): Growth Rate of AGRIVA, NETK; MACHI; ALANDand; IRRIG

Figure 1-(b) shows the trend of the annual growth rate of chemical fertilizers (1990-2020)

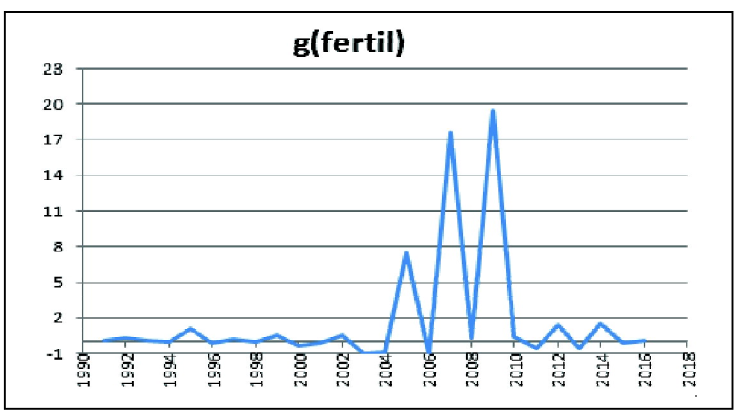


Figure 1-(b): Growth Rate of FERTIL

Figure 2 describes the linear relation between agricultural technologies and agricultural value-added. It indicates that the number of machines used, the number of hectares equipped for irrigation, and the number of hectares for arable land and permanent crops, are greatly related to the growth of agricultural value-added. Therefore, a linear model might explain correctly the relationship between the underlying variables, which may help to boost the growth of agricultural production in association with these underlying technologies. However, the agricultural gross domestic product is likely to be inexplicable to the number of chemical fertilizers in terms of linear relationships in this study.

Figure 2- (a) shows the relationship between machinery and agricultural value-added (1990-2021)and Figure 2-(b) the relationship between area equipped for irrigation and agricultural value-added (1990-2021)

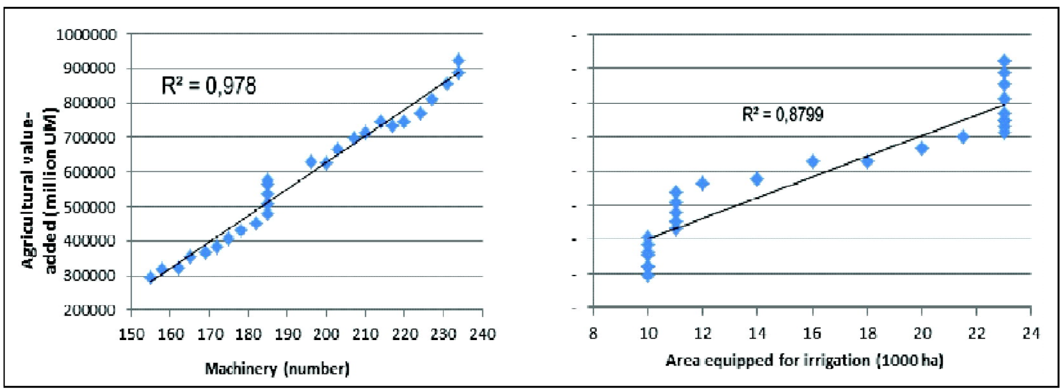


Figure 2-(a) and 2-(b): Relationship between Agricultural Value Added and Machinery and Area Equipped for Irrigation

Finally, Figure 2-(c) shows the relationship between chemical fertilizers and agricultural value-added (1990-2020), whereas Figure 2-(d) shows the relationship between arable land & permanent crop area and agricultural value-added (1990-2020).

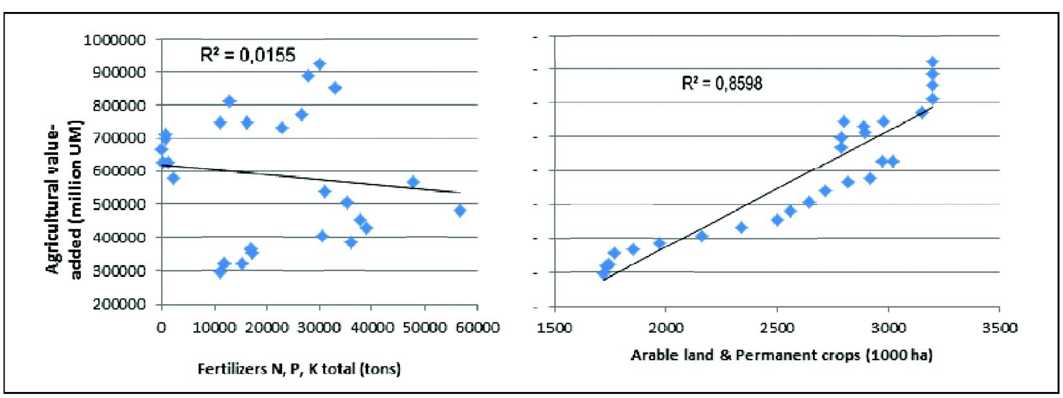


Figure 2-(c) 2-(d): Relationship between Agricultural Value Added and Fertilizers and Arable Land and Permanent Crops

7. RESULTS AND DISCUSSION

7.1. Unit-root Test

This study has considered the log of the data to avoid exponential trending before differencing. The Augmented Dickey-Fuller (ADF) tests in Table 3 show that the null hypothesis for each variable does have a unit root at a level that cannot be rejected. While the endogenous variable agricultural value-added (LAGRIVA) and five exogenous variables: Net capital stock (LNETK); Number of machines (LMACHI); Amount of credit to agriculture (LCREDI); Land equipped for irrigation (LIRRIG); and Chemical fertilizer consumed (LFERTIL)could not be rejected even at the 1% level – the rest of the four exogenous variables could not be rejected at the 5 % level. Then, all these variables were converted into the first difference or second difference (*LIRRIG*) for further analysis.

Table 3: The Augmented Dickey-Fuller Unit-Root Test on Variables: Results

Variables	*Unit-root test in*[2]	*ADF test statistic*	*Test critical values*	*Integration order*
LAGRIVA	First difference, including intercept	-6.926025	-3.724070***	I(1)
LNETK	First difference, without intercept nor trend	-2.730906	-2.660720***	I(1)
LMACHI	First difference, including intercept	-4.067870	-3.724070***	I(1)
LCREDI	First difference, without intercept nor trend	-11.40214	-2.664853***	I(1)
LENERG	First difference, without intercept nor trend	-4.898979	-2.660720**	I(1)
LLABOR	First difference, including intercept and trend	-3.924902	-3.673616**	I(1)
LALAND	First difference, without intercept nor trend	-2.077273	-1.955020**	I(1)
LFORES	First difference, including intercept	-3.674498	-2.986225**	I(1)
LIRRIG	Second difference, without intercept nor trend	-5.234235	-2.664853***	I(2)
LFERTIL	First difference, without intercept nor trend	-6.700149	-2.660720***	I(1)

***Indicates significance at the 1% level.

** Indicates significance at the 5% level.

Source: Suitably developed programs in R-Language

7.2. Estimation of parameters α_i

Based on equation (4), the growth of agricultural value-added is estimated as shown in Table 4, by running the relevant econometric model containing an autoregressive component. Moreover, two *dummy* variables (*Dum1, Dum2*) were introduced to capture respectively the impact of sectoral development policy and strategy and natural phenomena (e.g. flooding, precipitations). These variables influenced the growth of agricultural value-added since the null hypothesis that their coefficients are equal to zero cannot be accepted.

The regression model performs well, predicting 99% of the specified equation correctly. F-statistic was calculated to establish the causality between the growth of agricultural value-added and its determinant factors. All the diagnostic tests on the residuals coming from the long-run model estimation (serial correlation, heteroscedasticity, normality) are desirable.

Table 4: Estimation of the Growth of Agricultural Value-Added

	Sample $	
Variable	*Coefficient*	*S.E.*
Constant	-103.5374**	34.48855
YEAR	0.041686***	0.011901
LNETK	0.586066**	0.203309
LMACHI	0.886031**	0.352736
LCREDI	0.003155	0.004138
LENERG	0.958764	1.200274
LLABOR	-0.029977	0.488572
LALAND	0.383954***	0.094556
LFORES	1.766482	1.259222
LIRRIG	-0.268012***	0.082152
LFERTIL	-0.004634*	0.002418
Dum1	0.079432***	0.015338
Dum2	-0.045332**	0.016504
AR(3)	-0.688183**	0.275643
Adjusted R^2	0.997	
F-statistic	800.48***	
Durbin-Watson stat (DW)	2.358	
Sample$: 1990-2016 (N=27)		

***Indicates significance at the 1% level.

** Indicates significance at the 5% level.

* Indicates significance at the 10% level.

Source: Suitably developed programs in R-Language

7.3. Prediction of the growth of agricultural value-added

This section analyzes the gap between the forecasted value (*LAGRIVAF*) and the value of *LAGRIVA* estimated in section 5.2 named Actual value. The objective is to determine the goodness of fit of the estimated regression model. Fig. 3. (a) about the forecasted value indicates that the Root Mean Squared Error is set to only 1.146% and the curve of *LAGRIVAF* is passing through 95% of the confidence interval. The Theil Inequality Coefficient shows a perfect fit as well. As a result, we may conclude that the forecasted and actual *LAGRIVA* are moving closer, and then, the predictive power of the estimated regression model is quite satisfactory. This can be observed in Fig. 3-(b) where both *LAGRIVA* and *LAGRIVAF* are plotted together.

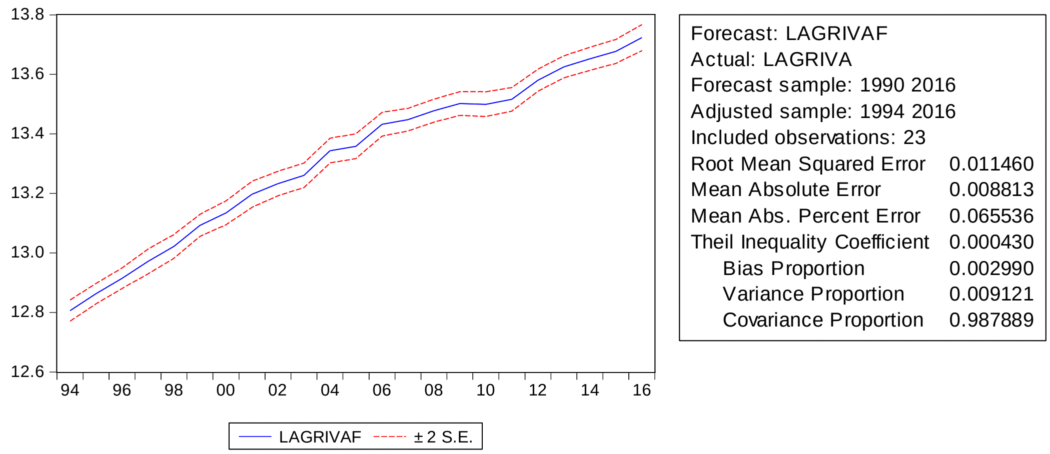


Figure 3 (a): Trend of Forecasted Growth of Agricultural Value-Added (1990-2021)

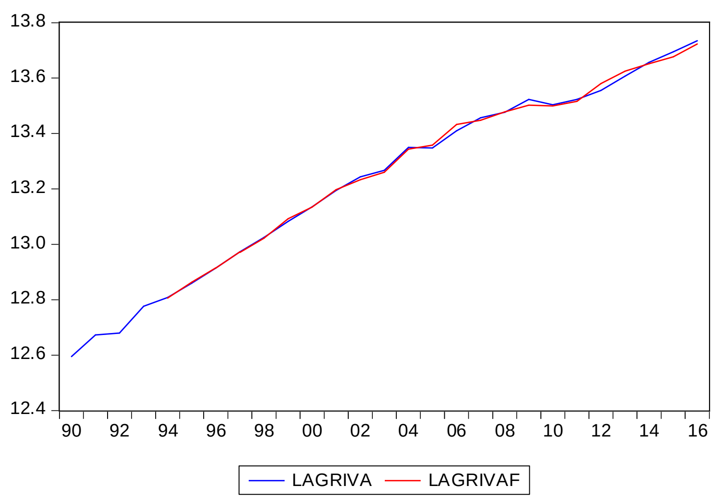


Figure 3. (b): Gap Between Actual and Forecasted Growth of Agricultural Value-Added (1990-2021)

Source: Suitably developed programs in R-Language

8. IMPULSE RESPONSE OF AGRICULTURAL PRODUCTION GROWTH

This section provides information on how agricultural value-added will further be reacting in the short, medium & long terms to a positive innovation or shock to agricultural technology. Analysis and the graphical presentation of the shocks to the net capital stock (LNETK), number of machines (LMACHI), number of hectares of arable land and permanent crops (LALAND), number of hectares equipped for irrigation (LIRRIG), and number of tons for chemical fertilizer (LFERTIL) and their effect on the agricultural value-added function was done using Cholesky (d.f. Adjusted) innovation with suitably developed R - Programming. The response is presented in Table 5.

Table-5: Impulse Response of Agricultural Value-Added (1-10 years)

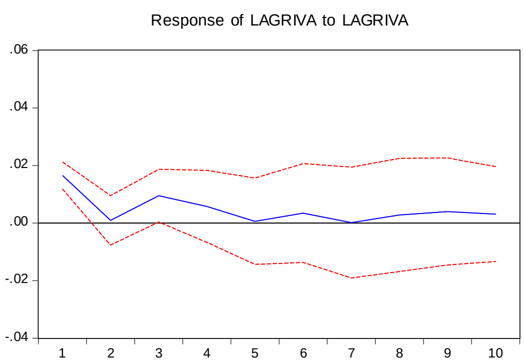
Period	*LAGRIVA*	*LNETK*	*LMACHI*	*LALAND*	*LIRRIG*	*LFERTIL*
1	0.016548	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.000938	0.001880	0.004575	0.003364	0.003025	-0.006375
3	0.009523	0.000622	0.008313	0.003506	-0.001925	-3.58E-06
4	0.005766	0.001267	0.011745	0.010891	-0.001772	-0.002663
5	0.000604	0.003451	0.007465	0.016807	-0.000977	0.003770
6	0.003461	0.005264	0.008238	0.018609	-0.005930	0.002293
7	0.000132	0.003888	0.005086	0.016867	-0.004091	0.001389
8	0.002821	0.002423	0.004726	0.012513	-0.004422	0.001753
9	0.004001	-5.71E-05	0.006643	0.009692	-0.003263	-0.000406
10	0.003092	-0.001353	0.006889	0.009398	-0.000784	0.001047

It is found that today's innovation in machinery (LMACHI) and arable land and permanent crops area (LALAND) in Bihar is continuously positive for the ten years [depicted in fig. 4. (c),(d)] and may be affecting positively and steadily the growth of agricultural value-added within 10 years (long term). Therefore, the goal of sustainable agriculture should rely on mechanized technologies and farming practices involving multi-cropping and agroforestry.

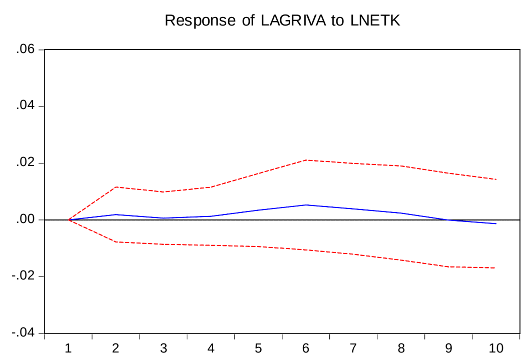
The growth of agricultural value-added in Bihar responding positively to a net capital stock (LNETK) is positive for the first 8 years but turns negative in the ninth and tenth years [depicted in Fig.4-(b)] which implies that in the short and medium terms (1-8 years) it may be positively affecting the growth of agricultural value-added, but it may be declining and turning into negative effects after 8 years (long term). Accordingly, it may be inferred that capital investments should be reinforced or renewed at opportune moments to keep steady the positive trend of agricultural economic growth over the years.

The growth of agricultural value-added in India may be responding negatively within 10 years further to a shock to irrigation technologies (LIRRIG) as indicated by Figure 4. (e). However, this negative response may be reversed after 10 years, indicating that once farmers do appropriate soil characteristics and other sub-factors relating to irrigation technologies management, these latter might impact positively the production growth. Meanwhile, the positive response of L*AGRIVA* to L*FERTIL*'s impulsion [Fig.4-(f)] is likely to dominate the negative effect in the long term (after 4 years). However, the impulse response is negative in the short term. For sustainable agricultural goals, it may be suggested that these chemical technologies should be applied in a balanced ratio.

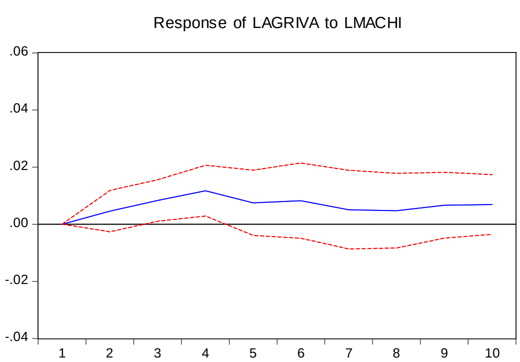
Furthermore, it is found that the output growth may be reacting successfully within 10 years when a shock is directly put into the overall production system [Fig. 4-(a)].



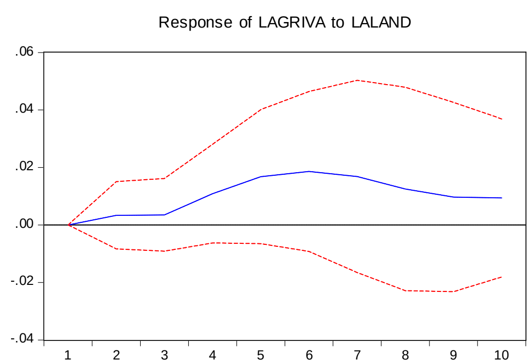
(a)



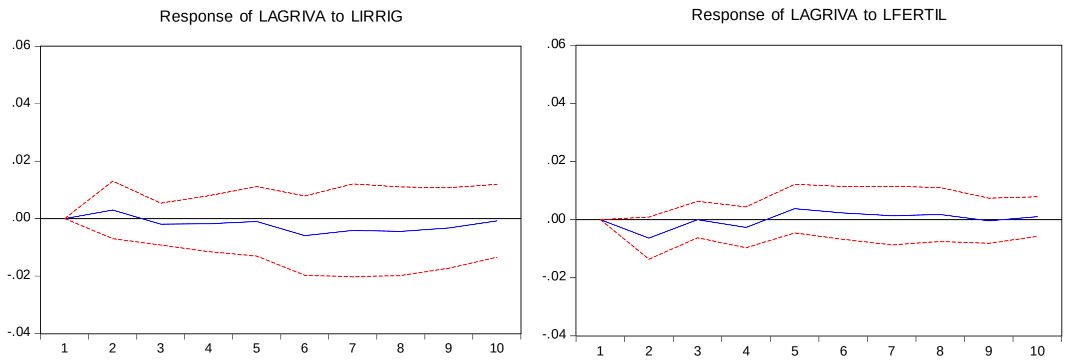
(b)



(c)



(d)



(e) (f)

Figure 4: Impulse Response of Agricultural Value-Added Growth(1-10 years)

9. AGRICULTURAL PRODUCTIVITY & INCOME GROWTH

The prime concern of policymakers is to boost agricultural productivity to supplement the growth of income for farmers. Analysis carried out in the previous sections indicates that large investment in capital stock in terms of mechanization supported by infrastructure and adoption of new farming devices at the opportune moment are the key instruments for this purpose. The Special Task Force on Bihar (Government of India, 2008) which suggested financial outlays of estimated Rs27055 crores over the period 2008-09 to2012-13 against the meager amount of Rs 1609 crores provisions in the 11th Five Year Plan had similar views. The current financial requirement for this purpose may be 1.5 – 2.0 % of the GSDP for the Agriculture Sector. Quantification of agricultural productivity and resulting income to farmers depend on the capacity of the public expenditure and the resulting crowding-in effect on the private investment, besides several factors operating in the system.

10. CONCLUSIONS AND RECOMMENDATIONS

This article leads to the following conclusion :

i) Technological progress appears to be a major determinant of boosting the potential productivity of land and affecting positively the growth of agricultural value-added in India through new farming devices and practices like multi-cropping, agro-forestry, new varieties of seeds, and new resource management.

ii) Investment in capital stock has shown a contribution of 13% in the present study (Table 2) and farmers have increased the agricultural value-added by 0.59 % with a 1% increase in the capital stock, provided supporting infrastructure such as roads is ensured.

iii) It has also been found that the contribution of the number of machines in increasing the agricultural value-added is 32%, so it is destined to capture the importance of agricultural mechanization (labor-saving technology)- which might foster the drop of some production inputs like labor and the saving of work time.

iv) The growth of agricultural value-added in Bihar responding positively to net capital stocks is positive for the first 8 years but turns negative in the ninth and tenth years [depicted in Fig.4.(b)] which implies that in the short and medium terms (1-8 years)may be positively affecting the growth of agricultural value-added, but it may be declining and turning into a negative effect after 8 years (long term). Accordingly, it may be inferred that capital investments should be reinforced or renewed at an opportune moment to keep steady the positive trend of agricultural economic growth over the years.

v) It is found that today's innovation in machinery and arable land and permanent crops area in India is continuously positive for the ten years [depicted in Fig. 4-(c)and,4-(d)] and may be affecting positively and steadily the growth of agricultural value-added within 10 years (long term). Therefore, the goal of sustainable agriculture should rely on mechanized technologies and farming practices involving multi-cropping and agroforestry.

vi) Permanent cropping may be encouraged as the contribution of the factor *ALAND* is established at approximately 21% in India. The number of hectares arranged for arable land and permanent crops is significant and influences positively the growth of the agricultural gross domestic product. Since this variable includes sustainable farming practices like multi-cropping, crop rotation, and agro-forestry, the probability that it is positively related to sustainable agricultural growth and as such the practice of agroforestry on farmland might be quite beneficial to the green agricultural revolution with some staple crops namely rice, corn, and wheat.

vii) Both the number of hectares equipped for irrigation and the number of chemical fertilizers appear to be negatively related to the growth of agricultural value-added. Many aspects must be considered in analyzing this outcome given that sometimes, the positive effects generated by applying land-conserving technologies may not compensate for their negative externalities. Currently, the pursuit of the agriculturally sustainable development goal in India not only relies on chemical fertilizers but also considers their mixture with organic manure.

viii) None of the variables *LABOR*, *FORES, CREDI*, and *ENERG* are found to be significant determinants of agricultural value-added growth. In other words, the underlying variables are not likely to foster increasing directly agricultural value-added.

These conclusions lead to the following recommendations :

a) Bihar may take a large-scale investment in agricultural capital as this factor appeared to be greatly related to the growth of agricultural production value.

b) Capital investments should be reinforced or renewed at opportune moments to keep steady the positive trend of agricultural economic growth over the years.

c) The capital investment in agricultural mechanization may lead to a drop in labor, which may impart skills for new farming devices and resource management practices.

d) The labor force strengthened with new knowledge and modern practices may have a significant role in multi-cropping, agro-forestry, adoption of new varieties of seeds, and increasing area for arable land and permanent crops- which could influences positively the growth of the agricultural gross domestic product.

e) The credit received by the farmers does not impact the growth of agricultural value-added. It needs to be examined whether the amount of credits is too insignificant to generate an increasing return to scale or if the amount vanishes due to imperfect management.

f) The contribution of the sub-sector of the forest seems to be negligible. However, out of their economic role, forests may be recognized as an environmental role like carbon dioxide sinks (positive externalities).

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