Review Article **AJAR (2019), 4:28**

American Journal of Agricultural Research (ISSN:2475-2002)

The Role of Information and Communication Technology (ICT) in Agriculture Productivity in India

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ABSTRACT

The study examined the role of ICT in agricultural productivity in India. It also analyzed the determinants of agricultural productivity. The causality test indicated the existence of long-run causality running from ICT and agricultural growth (AG) to economic growth. It showed bi-directional causality between agricultural growth and GDP. The long-run causality from ICT to AG was, however, uni-directional, implying the significance of ICT in agricultural growth. The determinants of agricultural productivity growth revealed increased machinery usage, investment in ICT, gross domestic capital formation and area under cultivation to be significantly contributing to increased productivity growth. The study suggests strengthening the effective implementation of ICT usage in Indian agriculture.

Keywords: Information and Communication Technology (ICT), Agriculture Productivity, India

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How to cite this article:
Manzoor Hassan Malik. The Role of Information and Communication Technology (ICT) in Agriculture Productivity in India. Natural resource modelling: accounting for gillnet size selectivity in dynamic deterrence model. American Journal of Agricultural Research, 2019,4:28.

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Website: http://escipub.com/

1.1 Introduction

Information and communication technology (ICT) has made significant contributions to the Indian economy, in terms of increased Gross Domestic Product (GDP), foreign trade, and employment generation. The rise of software industry, especially after economic reforms of 1990s, represents one of the most spectacular achievements of the Indian economy. The country has continuously maintained leadership position in global sourcing, accounting for almost 55 percent of the global sourcing market size in 2014, compared to the 52 percent in 2012. India is also the second largest telecommunication market in the world. Telephone subscribers have increased at a compound annual growth rate (CAGR) of 19.5 percent from 2007 to 2015. In 2015, the country's tele-density reached 80.98 percent, with 1022.61 million telephone subscribers during the same year. India has 13.5 percent share in world internet users, with a total number of internet users 354,114,747 in 2015 (Telecom Regulatory Authority of India).

Information communication technology assumes a vital role in the performance of all sectors of an economy. Information technology (IT) has emerged as a new factor of production. Modern agriculture has came to increasingly depend on information and communication technology, which includes information technology devices communication equipments and softwares. In developed nations, it has transformed the image of agriculture sector by raising efficiency in agricultural production, through its new information tools. Agricultural activities in these countries are based on web-linked database on different types of information, like climate, various Government schemes, price and demand information, and technical knowledge about farming (Rao 2007). It also has the potential to enhance the productivity and efficiency of agriculture sector, especially in developing countries.

India is mainly an agricultural economy, which plays a vital role in the socio-economic fabric of the country. She is the fourth largest exporter of agricultural commodities, accounting for 10 percent of the country's exports. The sector contributed nearly 14 percent of the Gross Domestic Production (GDP) during 2014-15 India. The agriculture and allied sectors has increased the value added from 137.17 US billion dollar in the financial year 2007 to 259.23 US billion dollar in the financial year 2015, accounting for 89.01 percent growth over the eight years period (Central Statistical Organization 2015). Besides, Approximately 60 percent of the country's population depends on agriculture sector for their employment and livelihood.

Digital divide prevents sections of the global society from partaking in the benefits of modernization, growth and development. Hence, in order to bridge the digital divide gap between rural and urban populations, diverse set of programmes of ICT have been launched in farming areas, as well as the overall economic development of the country. Public and private partnerships are emerging in case of ICT enabled initiatives, in the form of providing invaluable information about prices of the products, inputs, weather, and solving agricultural problems (such as, pesticide diseases and fertilizers), both at individual and community level.

Literature on the effects of ICT on agricultural growth has been mixed. Kramer and Dedrick (1994) found a positive relationship between IT investment and productivity growth in Asia Pacific countries for 1984-1990. Dewan and Kramu (1998) found that while IT investment was positively and significantly associated in developed countries, it was not significant in developing nations. Based on cross-country study, Pohjola (2000-02) reported a significant role played by ICT in economic growth of the developed countries. Timmer and Van (2008) observed investment in ICT to have significantly increased productivity, besides reducing transaction costs in developed countries. Ekanayake (2010) found agriculture production directed towards exports markets to be positively affected by investment in ICT sector. Erumban and Das (2015) concluded that the role of ICT investments was limited to the service sector, and was successful in raising the overall growth in India, but could not spread its spillover effects across the country. Against this backdrop, the objective of the present paper are:-

1. to examine the trends in ICT, agriculture growth and economic growth in India during 1980-2015;
2. to analyze the casual relationship among ICT, agricultural growth and economic growth; and
3. to analyze the influence of ICT and other factors on agricultural productivity.

1.2 Data and Methodology

The data for the study are collected from the Department of Telecommunication and Planning Commission, government of India for the period 1980-2015. The methodology adopted for studying the trends are simple averages, percentages, ratios, growth rates, diagrams and regression analysis. Cointegration and error correction model have been used for analyzing the casual relationship between ICT, agricultural share to GDP and economic growth in India. Investment in telecommunication industry and GDP at factor cost have been taken as the proxies for ICT and economic growth respectively.

The analysis is based on a system of equations, including the variables ICT, economic growth and agriculture share to GDP, all expressed in log form under the vector auto regression (VAR) model. The model is based on the following set of equations:-

$$\Delta LEG_t = \alpha_0 + Z_1 EC1_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta LEG_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta LAG_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta LICT_{t-i} + \varepsilon_{1t} \quad (1)$$

$$\Delta \mathrm{LAG}_t = \beta_0 + Z_2 EC2_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta LAG_{t-i} + \sum_{i=1}^{p} \beta_{2i} \Delta LEG_{t-i} + \sum_{i=1}^{p} \beta_{3i} \Delta LICT_{t-i} + \varepsilon_{2t} \quad (2)$$

$$\Delta \mathrm{LICT} = \gamma_0 + Z_3 EC3_{t-1} + \sum_{i=1}^{p} \gamma_{1i} \Delta LICT_{t-i} + \sum_{i=1}^{p} \gamma_{2i} \Delta LEG_{t-i} + \sum_{i=1}^{p} \gamma_{3i} \Delta LAG_{t-i} + \varepsilon_{3t} \quad (3)$$

where, z_1, z_2 and z_3 are the coefficients of error-correction terms in the equations (1), (2) and (3) respectively. These coefficients are expected to capture the long-run causality among the variables LEG, LAG and LICT. Whereas, ΔLEG_{t-i}, ΔLAG_{t-i} and $\Delta LICT_{t-i}$ are expected to capture the short-run causality among the variables.

Ordinary least square (OLS) multiple regression analysis has been adopted to estimate the influence of ICT and other factors on agricultural productivity. A regression analysis is concerned with the study of the dependence of one variable (i.e., the dependent variable) on one or more other variables (i.e., the explanatory variables), with a view to estimating and/or predicting the (population) mean or average value of the former in terms of the known or fixed (in repeated sampling) values of the latter. The first difference of the variables were taken. This is because all variables are I (1). The variables included in the regression model are growth rate of agricultural productivity, growth rate of investment in ICT, growth rate of net irrigated land, growth rate of gross domestic capital formation in agriculture sector, growth rate of agricultural machinery per 100 square kilometer of arable land, growth rate of area under cultivation and growth rate of value-added by labour. Growth rate of agricultural productivity is used as the dependent variable and the rest of the variables comprise the independent variables in the estimated multiple regression. To identify the influence of ICT and other factors on agricultural productivity, the following equation has been estimated:-

GAPDY = β_0 + β_1GRICT + β_2GIRLD + β_3GGDCF + β_4GMACH + β_5GARCL + β_6GVLAD + u

Where,

GAPDY = agricultural productivity growth rate;

GRICT = investment in ICT growth rate;

GIRLD = irrigated land growth rate;

GGDCF = gross domestic capital formation growth rate;

GMACH = machinery usage growth rate;

GARCL = area under cultivation growth rate;

GVLAD = value-added by labour growth rate;

u = error term; and

β = the slope coefficients.

Here, β is known as the regression coefficient, which is estimated using the principle of ordinary least squares.

The *a priori* expected association between the dependent and independent variables are positive for all input explanatory variables.

1.3 ICT Initiatives in Indian Agriculture: An Overview

Information and communication technology in India plays an important role in implementing the overall framework and regulatory policies, besides the estimating the progress of these polices. This helps in the development of the nation's regional and international trade. In agriculture and rural development, ICT supports development in various manners, like raising income of the farmers, social development, and entrepreneurships development. Various developmental service activities are also provided using ICT, include valuable information to the masses and governments, access to the market for inputs and products, and access to financial services (Veeramacheneni 2010).

Several ICT initiatives have been implemented in India, for the betterment of agricultural sector and the people associated with it for their livelihood. Some of major national ICT initiatives in agricultural sector carried out by public, private sector and non-governmental organizations (NGOs) are discussed here.

The National Institute of Agricultural Extension Management (MANAGE), established in 1987, is responsible for developing linkages among state, regional, and international institutions concerned with agricultural extension management. It develops and promotes application of modern management tools for improving the effectiveness of agricultural extension organization. Its main aim is to disseminate the benefits of technology innovations of the national agricultural technology project implemented with the help of World Bank, in association with the government of India. It provides internet connection for all participating agencies, agricultural researchers and the farmer clients in 28 districts in seven states. The project has set-up a network of information Kiosks for providing training and access to ICT for rural communities. These kiosks give information on farmer's rights, loans and grants. It also serves as a documentation center for collecting, storing, processing and disseminating information on subjects related to agricultural management (www.manage.gov.in).

Agricultural Marketing Information Network (AGMARKNET), launched in March 2000 by the Union Ministry of Agriculture, facilitates generation and transmission of prices, and commodity arrival information from agricultural markets, besides web-based dissemination of information to producers, consumers and traders. Its single window system caters to the needs of farmers, industry and academic institutions, by providing agricultural marketing information. About 3245 markets are covered under AGMARKNET, dealing with about 300 commodities and 2000 varieties across the country (agmarknet.gov.in).

The National Academy of Agricultural Research Management (NAARM) program, established by the Indian Council of Agricultural Research in 1976, addresses various issues like agricultural education and agricultural research management. It also renders services like patents and geographies indications to various stakeholders, including farmers. In order to raise rural income, it plays an important role in integrating national agriculture with agri-business. It has also set-up an agri-business knowledge center, for creation, dissemination, application and exchange of knowledge in agricultural area (www.naarm.ernet.in).

M. S. Swami Nathan Research Foundation (MSSRF) founded in 1988, works for the betterment of poor women in rural areas and disseminates information through its various database services. Its Farmer's Right Information services is a multi-media database on agro bio-diversity in India. Its information village research project uses ICT to impart market information, information on crops and fishing conditions to underprivileged villages. The Foundation aims to make use of ICT and modern science for agricultural and rural development. It disseminates the ICT services to improve the livelihood of tribal and rural communities. It follows a pro-poor, pro-women and pro-nature approach. It applies ICT options to address practical problems of rural population in agriculture, food, and nutrition. The Foundation has so far covered 6,00,000 individuals, and impacted livelihood of 1,00,000 farmers (www.mssrf.org).

The Indian Agricultural Universities, besides offering distance education to farmers and rural youth in learning production technologies, broadcast lessons, and organize content programs in which participants can discuss issues related to agriculture with agricultural scientists and experts. They also telecast video lessons in agricultural and allied fields and distribute cassettes to farmers, government and non-government organizations.

The Gyndoot launched on 0I January 2000, is a mass-based information internet service that connects rural cybercafés to internet and serves the rural people in Madhya Pradesh state of India. Under this scheme, computer centers are located on the roadsides of central villages, which people visit frequently. The scheme provides information about prices, and volumes of regional and national agricultural produce markets. The beneficiaries under this scheme have crossed one million (www.dhar.nic.in).

Indian Society of Agri-business Professionals (ISAP) e-group is a network of professionals across the (SAARC) countries, launched in 2001. It is probably the largest group of professionals, connected with agriculture around the world. It works to enhancing information exchange amongst the Indian agriculture professionals. It encourage farmers, farmer clubs and co-operatives to use this platform to raise queries about their produce, its availability, and also to reach out to large number of potential buyers. The group uses a mix of seminars and workshops, email discussion, telephony, SMS, and agro-clinics, to share information world-wide. It posts innovative idea on the group to inspire youths and others to dream of business and enterprises around agriculture. Its main aim is to change the lives of two million odd people, who are partly or fully dependent on agriculture for their livelihoods. It has worked with 3,00,000 farming families across India (www.isapindia.org).

The E-choupal program launched in 2000, directly deals with rural farmers for procurement of agriculture products, like soybeans, wheat, coffee and prawns. The program aims to overcome various challenges of Indian agriculture, like fragmented farm and weak infrastructure. It also installs computer centers in rural areas of India to provide farmers up-to-date agricultural and marketing information. It enables farmers to obtain information on mandi prices, good farming practices, and place orders for inputs like seeds and fertilizers. The program has removed the role of intermediaries, because farmers can directly strike orders through internet kiosks. There are 65,000 E-choupals working in 10 States, benefiting more than 4.0 million farmers (www.itcportal.com).

India agriline project is designed to enhance e-commerce in the agriculture sector. Under this project, the farmers gets all required information. Internet kiosks are designed to fulfill the agricultural and commercial needs of the rural communities. It covers 2.8 million people through farm inputs, sugarcane procurements, intensive area development programmes (IADP) and extension services (www.indiagriline.com).

The All India Radio Farm School Program since 2011, is the most effective communication system in rural agriculture markets in the country. It helps in mitigating the gap between the agricultural scientists and farmers. It produces and transmits varied programs on agriculture with special emphasis on social minorities, like tribal population, border regions and remote areas. Its farm section monitors covers the needs of rural listeners about the day to day seasonal needs of the farmers in different languages, through more than 188 radio stations across the country (www.iihr.ernet.in).

Kissan call centers launched on 21 January 2004, are vital information source centers of farmers, regarding good agricultural practices, crop related information, diseases and pest control. The program aims to deliver services to the farmers in their local languages. They can call helpline numbers, where responses to their queries are offered by agricultural experts. It works at two levels: firstly, responses to queries raised by farmers are provided by experts instantaneously, and secondly, queries are examined by experts and if there is a need, agricultural experts also visit the farms (dackkms.gov.in).

Thus, Information communication technology (ICT) plays an important role in improving the essential service provisions to the agricultural society in India. The growing importance of ICT in India's agriculture sector is now a fact rather than a promise. But, India has a low ICT development index, as compared to other developing countries. There is still a long way to go to make effective diffusion of information communication technology in the agriculture sector in India, where a large of the population is dependent on it for employment and livelihood.

1.4 Empirical Results

Table-1 shows trends in GDP, share of agriculture in GDP and investment in telecommunication industry during 1980-2015.

Table-1 Trends in GDP, Share of Agriculture in GDP and Investment on Telecommunication Industry

Year	GDP in Rs. Crores	Growth Rate (%)	Share of Agriculture Rs. Crores	Growth Rate (%)	Investment on Telecommunication in Rs. Crores	Growth Rate (%)
1980	798,506	-	285,015	-	1883	-
1985	1,013,866	26.98	333,616	17.06	3195	69.68
1990	1,347,889	32.95	397,971	19.30	6438	101.51
1995	1,737,741	28.93	447,127	12.36	11555	79.49
2000	2,342,774	34.82	522,755	16.92	15915	37.74
2005	3,253,073	38.86	594,487	13.73	25817	62.22
2010	4,918,533	51.20	717,814	20.75	35719	38.36
2015	6,261,150	27.30	872,624	21.57	45621	27.73
Period	GDP in Rs. Crores	Average Growth Rate (%)	Share of Agriculture Rs. Crores	Average Growth Rate (%)	Investment on Telecommunication in Rs. Crores	Average Growth Rate (%)
Pre 1991	3,160,261	19.98	10,16602	12.11	11,516	57.06
Post 1990	18,513,271	36.22	31,54807	17.06	13,4627	49.11
Combined	21,673,532	34.43	41,71409	17.37	14,6143	59.53

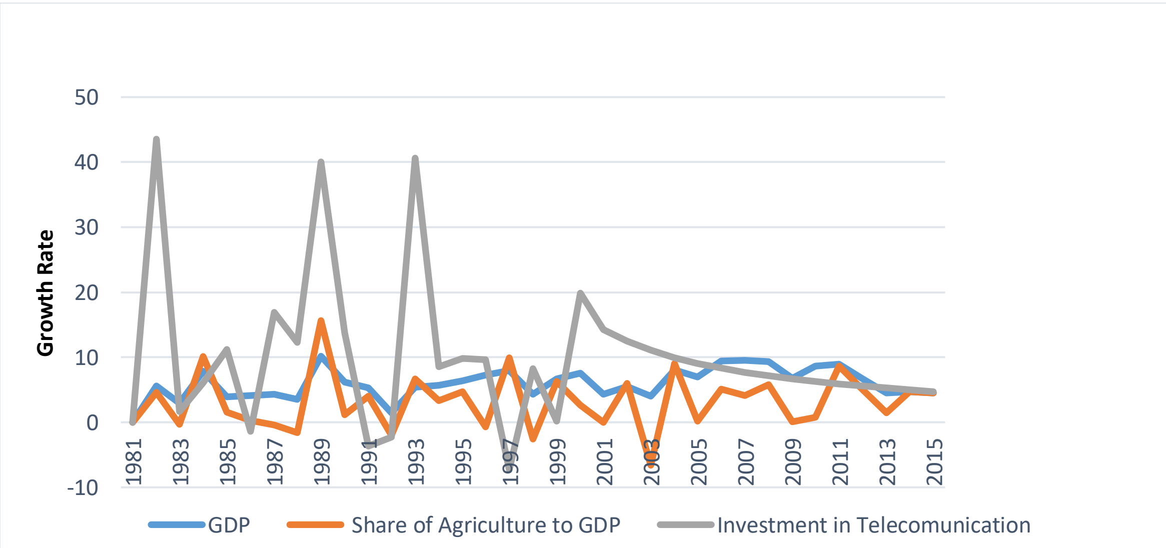
Source: Own calculations from Planning Commission Government of India data.

The table shows that GDP of India increased from Rs. 789,506 crores in 1980 to Rs. 6,261,150 crores in 2015, rising at an average of Rs. 2709191.5 crores during the study period 1980 to 2015. GDP grew at an average growth rate of 30.13 percent during the same period. India's GDP growth rate increased continuously from 1990, 28.93 percent upto the 2010, 51.20 percent but decreased to 27.30 percent in 2015. The global economic slowdown in U.S.A which came in the same period may be reason for decline in GDP growth during the period 2010-15. The share of agriculture sector to GDP increased from Rs. 285,015 crores in 1980 to Rs. 872,624 crores in 2015, with moderate fluctuations upto 2005. It rose at an average growth rate of Rs. 15.21 percent during the study period 1980 to 2015. As regards investment in telecommunication sector, it increased from Rs. 1883 crores in 1980 to Rs. 45621 crores in 2015, rising at an average of Rs. 18267.875 crores during the period 1980 to 2015. Investment in telecommunication sector grew at an average of 52. 09 percent during the same period.

The table also shows that GDP of India during 1980-90 grew at an average growth rate of 19.98 percent during the period 1980-90. It increased from Rs. 3,160,261 crores in pre-1991 period to Rs. 18,513,271 crores in post-1990 with a significant average growth rate of 36.22 percent in the post-reforms period against the combined average growth rate of 34.43 percent. The share of agriculture sector to GDP increased from Rs. 10,16602 crores in pre-1991 period to Rs. 31,54807 crores in the post-1990, grew at an average growth rate of 17.06 percent in the post-reforms period against the combined average growth rate of 17.37 percent. Investment in telecommunication sector increased from Rs. 11,516 crores in pre-1991 period to Rs. 13,4627 crores in the post-1990 period, grew at an average of 49.11 percent in the post-reforms period against combined average growth rate of 59.53 percent.

The discussed trends are illustrated using a diagram. Figure-1 shows growth rates in GDP, share of agriculture to GDP and investment in Telecommunication industry.

Figure-1 Growth rates in GDP, Share of agriculture to GDP and Investment in Telecommunication Industry



Source: Own calculations from Planning Commission Government of India data.

Figure shows growth rates of the three variables, viz., GDP, share of agriculture to GDP and investment in Telecommunication industry used for analyzing the causal relationship both in the short-run and long-run. Both the series share of agriculture to GDP and investment are following the GDP growth during the period 1980-2015. However the fluctuations are higher in case of investment in ICT as compared to the share of agriculture to GDP.

Table-2 shows descriptive statistics of all variables in pre-1991, post-1990 and total study period (1980-2015).

Table-2 Descriptive Statistics of key Variables: Pre 1991, Post 1991and Combined Periods

Pre 1991 Period			
Descriptive Statistics	LEG	LAG	LICT
M	13.839	12.718	8.210
M	13.829	12.713	8.083
Max.	14.114	12.894	8.807
Min.	13.590	12.560	7.540
Σ	0.172	0.108	0.403
m_3	0.173	0.241	0.192
m_4	1.890	2.014	2.058
J-B	0.618(0.74)	0.552(0.76)	0.473 (0.79)
Post 1991 Period			
Descriptive Statistics	LEG	LAG	LICT
M	14.860	13.251	9.865
M	14.798	13.234	9.944
Max.	15.649	13.679	10.728
Min.	14.114	12.874	8.746
Σ	0.5038	0.235	0.618
m_3	0.0953	0.178	-0.232
m_4	1.695	1.997	1.782
J-B	1.883(0.40)	1.228(0.55)	1.841(0.39)
Combined Period (1980-2015)			
Descriptive Statistics	LEG	LAG	LICT
M	14.569	13.099	9.391
M	14.519	13.123	9.360
Max.	15.649	13.610	10.728
Min.	13.591	12.561	7.541
Σ	0.182	0.324	0.957
m_3	0.182	0.054	-0.278
m_4	1.782	1.933	1.853
J-B	2.425(0.30)	1.724(0.42)	2.438(0.29)

Note: μ - mean; M – median; Max. – maximum; Min. – minimum; σ – standard deviation; m_3 - Skewness; m_4 - kurtosis; J-B – Jarque-Bera test for normality respectively; figures in parenthesis are respective p-value.

It is observed that the series of LEG, LAG and LICT are normally distributed in all three periods. This is confirmed by the Jarque-Bera statistics, which cannot reject the null hypothesis of normal distribution at one percent level of significance

Table-3 gives information on ICT tools used in agricultural activities in India.

Table-3 ICT Applications in Agricultural Activities

Sl. No.	ICT Tools	Activities
1	Internet and Broadband	Knowledge sharing, Social media, e-community, Market platform and trading.
2	Computers and Websites	Agriculture information and markets.
3	Sensor Networks	Real time information, Better data quantity and quality, Decision making.
4	Satellite	Weather universal accessibility, Remote sensing
5	Data Storage and Analytics	Precision agriculture, Actionable knowledge.
6	Telephone	Interactive voice response
7	Broadcasting	Expertise sharing, Advisory
8	Mobile	Advisory, Sales, Banking, Networking.

Source: International Telecommunication Unit.

The efficiency of the model has been tested for the presence of serial correlation and heteroscedaticity, besides normality of residuals. Breusch-Godfry serial correlation test has been used to verify the presence of serial correlation. The test shows no evidence of no serial correlation in the model. Further, the Auto Regressive Conditional Heteroscedaticity (ARCH) test indicates that there is no ARCH effect in the model. The normality of residuals is confirmed by the Jarque-Bera statistic. Therefore, the result holds that residuals are normally distributed.

Prior to performing the Cointegration test, test of order of integration for each variable using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests have been conducted. Their results are presented in table-4.

Table-4 Unit Root Tests

Variables	ADF Levels	ADF First Difference	PP Levels	PP First Difference
LEG	-2.093	-4.359*	-1.800	-4.348*
LAG	-2.634	-9.881*	-4.497	-21.351*
LICT	-2.501	-6.944*	-2.522	-10.963*

Note: * indicate significant at one percent level.

The results show that the null hypothesis that there is presence of unit root is not rejected at the levels for all variables. However, the null hypothesis is rejected against the alternative hypothesis that there is presence of unit root, when the first difference of the variables are taken. Thus, the first difference of all variables are found to be stationary, and hence all the series are integrated of order one. The tests of unit root support the unit root hypothesis at one percent level of significance for all variables.

Since the existence of unit root for all the variables is confirmed, the next step is to conduct Cointegration test. The Johanson Cointegration test results are presented in table-5.

Table-5 Johanson Multivariate Cointegration Tests

Trace Test			
	Null Hypothesis	Alternative Hypothesis	Trace Statistic
	r = 0	r > 0	(42.689)*
	r ≤ 1	r > 1	(12.168)**
	r ≤ 2	r > 2	(4.323)
Maximum Eigen-value test			
	Null Hypothesis	Alternative Hypothesis	Max-Eigen statistic
	r = 0	r = 1	(30.521)*
	r = 1	r = 2	(7.845)**
	r = 2	r = 3	(4.323)

Note:* and ** indicates significance at one and five percent level respectively.

The results support the existence of two cointegrating equation, implying that the three variables ICT, agricultural share to GDP and economic growth are cointegrated. Thus, the test indicates that there exists a long-run relation between the variables, or that all the variables ICT, agricultural share to GDP and economic growth are moving together in the long-run.

According to Granger (1969), when time series X Granger-causes time series Y, past values of X can be used to forecast the future values of Y. Having confirmed the existence of long-run association among the variables, the next step is to find the causal relationship among the given variables. The presence of cointegration allows to use the Vector Error Correction Granger causality, which manifests both in the short-run as well as long-run causality.

Table-6 VCEM Granger Causality Results

Dependent Variable	ΔLEG	ΔLAG	ΔLICT	Error Correction Term
ΔLEG	-	2.648 (0.266)	0.860 (0.651)	-0.338* (0.018)
ΔLAG	1.699 (0.428)	-	0.795 (0.671)	-0.752** (0.032)
ΔLICT	2.213 (0.330)	2.172 (0.337)	-	-0.429 (0.569)

* and ** indicates significant at 1 and 5 percent level respectively; and Numbers in the parentheses are P-values.

Table-6 presents the estimated results of Vector Error Correction model. It shows the error correction term for cointegrating equation with LEG, LICT and LAG as dependent variables. In the table error term with ICT (-0.429) as dependent variable is not significant. Therefore, it reveals that EG and AG does not cause ICT in the long-run. However, the long run coefficient with LEG (-0.338) and LAG (-0.752) as dependent variables are significant.

In sum, the first finding of the analysis is that there is long-run causality running from ICT and AG to economic growth (GDP). This finding is consistent with the theory on ICT and growth that ICT does lead to economic growth (Dewan and Kreamer 1998). The next finding of the analysis shows evidence of bi-directional causality between agricultural growth (AG) and GDP, which is also consistent with the findings reported in existing literature (Pohjola 2000). The third finding of the analysis indicates a uni-directional causality running from ICT to AG, implying that ICT is an important determinant of AG in India. However, the results reveal that there are no short-run causality among the variables. It also presents chi-square and probability in brackets for Granger Causality tests.

Table-7 reports the ordinary least square regression results of the agricultural productivity growth rate function.

Table-7 OLS Regression Results: Agricultural Productivity Function.

Sl. No.	Variables	Coefficients
1	Constant	104.083(17.48)*
2	GRICT	0.051(1.836)***
3	GIRLD	2.291(0.117)
4	GARCL	0.132(1.841)***
5	GVLAD	1.154(1.502)
6	GGDCF	0.011(7.251)*
7	GMACH	54.443(5.264)*
8	Adjusted-R^2	0.87
9	F-Value	38.160

Note: Brackets show t-value; and *, ** and *** indicate significance at 1, 5, and 10 percent levels respectively.

Growth rate of investment in ICT (GRICT) is positively and significantly related to agricultural productivity, indicating that an unit increase in investment in ICT significantly increases agricultural productivity by about 0.051 units. Dissemination of information through different ICT schemes have positive, but not strong bearing on agricultural productivity, as there are other hindrances to effective utilization of ICT potentials in the Indian context, like illiteracy, willingness to adopt new technology, easy accessibility, availability of relevant or localized contents in own languages, especially in the rural areas. Hence, there is still a long way to go to make the farmers understand and to motivate the importance of ICT usage in agriculture sector.

Machinery used per 100 square kilometer (GMACH) has the strongest and positive bearing on agricultural productivity. One unit increase in it significantly increases agricultural productivity by 54.443 units. Gross domestic capital formation (GGDCF) and area under cultivation (GARCL) in agriculture are also positively and significantly related to agricultural productivity, contributing to 0.011 and 0.132 units increase respectively.

The effects of change in net irrigated land (GIRLD) and value-added by labour (GVLAD) are positive, but not significant on agricultural productivity. The R^2 value implies that the included explanatory variables describe 87 per cent of the total variations in the dependent variable. The overall fitted model emerges statistically significant.

1.5 Conclusion

The growing importance of ICT in agriculture sector in India is now a fact, rather than a mere promise. It plays a vital role in improving the essential service provisions to the agricultural society. The paper analyzed the role of ICT in agricultural productivity in the country during the period 1980-2015. It also examined the determinants of agricultural productivity growth rate.

Cointegration and error correction mechanism were used to analyze the casual relationship among the ICT, AG and EG in India. The results of the multivariate cointegration suggested that the existence of a long-run causality, running from ICT and AG to economic growth (GDP). It showed evidence of bi-directional causality between agricultural growth (AG) and GDP, which is consistent with the existing literature (Pohjola 2000). The study also indicated uni-directional causality running from ICT to AG in the long-run. It implies that ICT is an important determinant of AG in India. Thus, the results support the evidence that ICT fuels economic growth in India.

Further, the influence of ICT and other factors on agricultural productivity were examined, using multiple regression model. The regression results suggested that changes in machinery usage, investment in ICT, gross domestic capital formation and area under cultivation exercise positive and significant impact on change in agricultural productivity, with change in machinery usage having a strong bearing on agricultural productivity in India.

In sum, the study indicates that there is still a long way to go to achieve effective diffusion of information and communication technology in the Indian agriculture sector.

References

1. Abraham Vinoj (2010), “Regional Skill Suppliers and Location of Firms: The Case of Information Technology Industry in India”, MPRA Paper No. 28424, Centre for Development Studies (JNU), Kerala, India, pp. 1-27.
2. Agricultural Marketing Information Network, http://agmarknet.gov.in.
3. Arora, Ashish and Athreye Suma (2002), “The Software Industry and India’s Economic Development”, Information Economics and Policy, Vol. 14, No. 14, pp. 253-273.
4. All India Radio Farm School Program, http://www.iihr.ernet.in.
5. Bhatt, Sheela and Sarangdevot, S.S., (2013), “Potential of Information and Communication Technology towards the Success of the Indian IT Software Industry”, Journal of Computational Engineering Research, Vol. 3, No. 1, January, pp.159-166.
6. Chaudhuri (2012), “Creeping Tiger, Soaring Dragon: India, China and Competition in Information Technologies”, China and World Economy, Vol. 20, No. 6, pp. 1-28.
7. Dewan s. and kraemer k. (1998), “information technology and productivity paradox”, communication of the ACM, Vol. 41, No. 8, August, pp. 1-7.
8. Dewan Sanjeev Kraemer L. Kenneth, (2000), “Information Technology and Productivity: Evidence from Country-Level Data”, Management Science, Vol. 46, No. 4, April, pp. 548-562.
9. Erumban A. Abdul, Das Kusum Deb. (2015), “Information and communication technology and economic growth in India”, Telecommunications Policy. August, pp. 1-20.
10. Granger, C.W.J. (1969), “Investigating Causal Relations by Econometric Models and Cross-spectral Methods”, Econometrica, Vol. 37, No. 3, August, pp. 424-434.
11. Greene H. William (2003), Econometric Analysis, Pearson Dorling Kindersley, Panchsheer Park, New Dehli, pp. 649-657.
12. Gujarati, D.N and Sangeeta (2002), Basic Econometrics, Tata McGraw-Hill Publishing Company Limited, New Delhi, pp. 396-450.
13. Hutchinson, Francis and Ilavarasan Vigneswara (2008), “The IT-ITES Sector and Economic Policy at the Sub-national Level in India”, Economic and

Political Weekly, Vol. 43, No. 46, November 15-21, pp. 64-70.

14. ICT Rural Development in Agriculture, http://www.indiagriline.com.
15. Indian society of agri-business professionals, http://www.isapindia.org.
16. Imperial Tobacco Company of India Limited, http://www.itcportal.com.
17. Institute of Indian Council of Agricultural Research, http://www.iihr.ernet.in.
18. International Telecommunication Union (ITU), World Telecommunication Indicators Database, http://www.itu.int.
19. Jain, Ravindra and Agrawal Richa (2007), "ICT Education and Training Services: Current Scenario and Future Pospect in India", Journal of Business Perspective, Vol. 11, No. 2, April, pp. 41-55.
20. Joseph k., (2002), "Growth of ICT and ICT for development: Realities of the Myths of the Indian Experience", Dscussion Paper No. 78, World Institute for development Economics Research, pp. 1-35.
21. Kisaan Knowledge Management System, http://dackkms.gov.in.
22. Kraemer k., and Dedrick J. (1994) "Payoffs from Investment in Information Technology: Lessons from the Asia-Pacific Region", World Development, Vol. 22, No. 12, pp. 1921-1931.
23. Majmadar Summit K., Davina Vora and Nag Ashok (2010), "Legal Form of the Firm and Overseas Market Choice in India's Software and IT Industry", Asia Pacific Journal of Management, 10 Aug, pp. 659-687.
24. Manoj P.K. (2007)," ICT Industry in India: A Swot Analysis", Journal of Global Economy, Vol. 3, No. 5, October, pp. 263-282.
25. NASSCOM (2014-15), Information Technology Annual Report, http://www.nasscom.org.
26. National Institute of Agricultural Extension Management, http:// www.manage.gov.in.
27. Pohjola M. 2000, "Information Technology and Economic Growth: A Cross-country Analysis", United Nations University, Working Paper No. 173.
28. Pritish and Saxena Taruna, (2015), "An Analysis of the Indian Telecom Industry", Journal of Business and Management, Vol. 17, No. 10, October, pp. 35-42.
29. Rao H. N, (2007), "A Framework for Implementing Information and Communication Technologies in Agricultural Development in India" Technological Forecasting and Social Change", Vol. 17, No. 4, February, pp. 491-518.
30. Simon, Jean Paul (2011), "The ICT Landscape in BRICS Countries: Brazil, India, China", JRC Scientific and Technical Report, European Commission, World Trade Center, pp. 44-47.
31. Singh Nirvikar, (2006),"ICTs and Rural Development in India", Working Paper No-UC Santa Cruz: Department of Economics, University of California, October, pp. 1-118.
32. Swai Nathan Research Foundation, http://www.mssrf.org.
33. Telecom Regulatory Authority of India (2015), Indian Telecom Services Performance Indicator report, http://www.trai.gov.in.
34. The NAARM program, http:// www.naarm.ernet.in.
35. Veeramacheneni, Vogel and Ekanayake, (2010),"Information Technology and Agricultural Exports in India", Southwestern Economic Review, January, pp. 17-27.
36. World Bank (1993), Informatics and Economic Modernization, World Bank, Washington, D.C.